LIVERPOOL

GEOLOGICAL ASSOCIATION.

TRANSACTIONS.

VOLUME V.

SESSION 1884-5.

LIVERPOOL:
PUBLISHED BY HENRY YOUNG, 12, SOUTH CASTLE STREET.

1885.

TWO SHILLINGS AND SIXPENCE.

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INDEX.

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The Authors are alone responsible for the facts and opinions expressed in their Papers.

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ILLUSTRATIONS.

Erratum.

Page 36, line 20, for "Wariau," read "Wairau."

LIVERPOOL

GEOLOGICAL ASSOCIATION.

ANNUAL REPORT,

1884.

LIVERPOOL GEOLOGICAL ASSOCIATION,

FREE LIBRARY, WILLIAM BROWN STREET, LIVERPOOL.

Council,

PRESIDENT.

HENRY BRAMALL, M. INST. C.E.

VICE-PRESIDENT.

CHARLES E. MILES.

MEMBERS OF COUNCIL.

DANIEL CLAGUE.

H. T. MANNINGTON.

ISAAC E. GEORGE.

JOHN MORRIS.

J. R. WEBB.

TREASURER.

WILLIAM H. WALKER,

40, Castle Street, Liverpool.

SECRETARY.

D. CLAGUE,

81, Lime Grove.

THIS COUNCIL WILL CONTINUE UNTIL OCTOBER, 1885.

LIVERPOOL GEOLOGICAL ASSOCIATION.

ANNUAL REPORT,

Session 1883-84.

6th October, 1884.

The termination of another Session affords your Council the pleasure of again presenting their Annual Report.

The number of members elected since the last Annual Meeting is 29. During this period 10 resignations have been received. The members now on the roll number 146.

The past Session has comprised 10 Evening Meetings, at which the ordinary business of the Association has been transacted; various mineral and other interesting geological specimens have been exhibited; brief communications from members received, and the following Papers have been read and discussed.

THE PRESIDENT'S ADDRESS by Henry Bramall, M. Inst C.E.

"ON THE DENUDATION OF LIMESTONE," by Isaac E. George

"ON METHODS OF STUDY IN CHEMICAL GEOLOGY," by A. Norman Tate, F.I.C.

"ON THE BOULDER CLAY OF CHESHIRE, AND THE ERRATICS CONTAINED IN IT." by Dr. C. Ricketts, F.G.S.

"ON THE SUBSIDENCES IN THE SALT DISTRICTS OF CHESHIRE, AND THEIR GEOLOGICAL CAUSE," by Thomas Ward.

"MINERAL SPRINGS," by Charles E. Miles.

"THE PROPERTIES OF TRIASSIC SANDSTONE," by Isaac Roberts, F.G.S., F.R.A.S.

"THE GOLD FIELDS OF BRITISH COLUMBIA," by the Hon. H. Holbrook.

"PTERODACTYLES," by Anthony W. Auden.

"THE GEOLOGY OF THE ISLE OF MAN," by Daniel Clague.

Field Meetings have also been held on—

1884.

14th April. Llandudno. Leader—Mr. Isaac E. George.

17th May. New Brighton. Leader—Mr. P. H. Marrow.

7th June. Northwich. Leader—Mr. Thomas Ward.

14th June. Ravenhead. Leader—Rev. H. H. Higgins, M.A.

18th June. (Evening) Otterspool. Leader—Mr. C. Potter.

28th June. Storeton, (With the Liverpool Geological Society
Leader—Mr. G. H. Morton, F.G.S.

12th July. Heswall, (With the Liverpool Science Students' Association.) Leader—Mr. C. E. Miles.

17th July. (Evening) Bebington. Leader—Mr. C. E. Miles
The Mayer Library grounds and Museum were visited on this occasion by permission of Mr. Joseph Mayer, F.S.A.

26th July. Ormskirk. Leader—Mr. Isaac Roberts, F.G.S.

16th Aug. Prescot. Leader—Dr. C. Ricketts, F.G.S.

30th Aug. New Brighton. Leader—Mr. C. Potter.

The Excursions have been superintended by the following Committee :—

Messrs. George Robson, D. Clague, John Morris, and W. H. Miles.

During the winter months, a series of visits to the Brown Museum were made on Saturday afternoons.—

1883.

On 8th Dec., Mr. F. P. Marrat gave an "Explanation of the Cases illustrative of the Tertiary shells."

1884.

On 12th Jan., Mr. T. J. Moore, Cor. Mem. Z.S. gave "Illustrations of Fossil Ruminant Mammalia from the Sivalik Hills of North West India; and Dr. Murie's views as to the relationship of *Sivatherium* to recent forms."

On 9th Feb., Mr. D. Clague explained "The relations of the Palæozoic Fossils," and

On 8th March, Mr. Thomas Brennan described "The Fossils of the Oolitic and Cretaceous Periods."

As these visits were of a practical and useful character, the Council propose that a similar series should be made during the winter.

Through the liberality and kindness, and under the guidance of Mr. A. Norman Tate, F.I.C., (who gave his services and the use of his laboratory to the Association for the purpose,) a course of five "Practical Meetings" for the study of chemical and other tests for the determination of rocks and minerals, was held during the winter months.

The Council are pleased to state that the Library has proved increasingly useful and has been enriched by several donations of considerable value. With a view of extending its usefulness still further, it is proposed to purchase a series of Geological Maps, and a fund for this purpose has been opened. The thanks of the Association are due to—

Messrs. Henry Bramall, M. Inst. C.E.; J. M. Barber; T. R. Connell; J. C. Evans; H. G. Fordham, F.G.S.; Dr. Henry Hicks, F.G.S.; Hon. H. Holbrook; George Lewis; C. E. Miles; John Morris; C. Potter; T. Mellard Reade, F.G.S.; C. Rowett; Isaac Roberts, F.G.S.; Dr. Alfred R. C. Selwyn, F.R.S.; Elisha Smith; W. Whitaker, B.A., &c, who have presented Books to the Library.

The Association exchanges publications with the following Societies and Institutes:—

Belfast Naturalists' Field Club.
Birmingham Free Library.
Burnley Literary and Scientific Club.
Chester Free Library.
Chester Society of Natural Science.
Edinburgh Geological Society.
Geological and Natural History Survey of Canada.
Lancashire and Cheshire Entomological Society.
Liverpool Amateur Photographic Association.
,, Astronomical Society.
,, Engineering Society.
,, Free Library.

Liverpool Geological Society.
,, Law Students' Association.
,, Literary and Philosophical Society.
,, Naturalists' Field Club.
,, Philomathic Society.
,, Science Students' Association.
Local Scientific Societies Committee, (British Association
London Geologists' Association.
Manchester Geological Society.
Manchester Scientific Students' Association.
Mining Institute of Cornwall.
North of England Institute of Mining and Mechanical Engineers.
Norwich Geological Society.
Royal Geological Society of Cornwall.
Smithsonian Institution, Washington, U.S.A.
Wagner Free Institute of Science, Philadelphia, U.S.A.
Yorkshire Philosophical Society.

The publication of the "Transactions" has been continued; the concluding part of the fourth volume having been issued in September.

The Session has been a busy one, and the Council congratulate the members on the success which has been attained. The Council have pleasure in acknowledging the assistance which has been rendered by, and the valuable suggestions which have been received from several members from time to time; as these indicate continued interest in the progress and welfare of the Association.

The Treasurer's Financial statement, duly audited in accordance with the Laws, is appended to this report. After providing for all liabilities, there remains a balance of cash in hand of £2 7 5

The Officers of the Association now retire in conformity with Law III. The Council for Session 1884-8: will, therefore, require to be elected at this meeting.

LIVERPOOL GEOLOGICAL ASSOCIATION, *In Account with the Treasurer.*

FOR THE YEAR ENDING SEPTEMBER, 1884.

Disbursements.

Date		£	s	d
1884				
Sept.	To Rent of Room	2	10	0
,,	,, Printing and Stationery	23	10	10
,,	,, Postages and Incidentals	9	11	1
,,	,, Balance	2	7	5
		£37	19	4

Receipts.

Date		£	s	d	£	s	d	£	s	d
1883 Sept,	By balance brought forward							1	6	3
1884 Sept.	,, SUBSCRIPTIONS, viz—									
	,, 146 Members, at 5s.				36	10	0			
	,, 5 Members paid in advance last year	1	5	0						
	,, 19 Members in arrear	4	15	0	6	0	0			
	24									
	122 Subscriptions for the year 1883-84				30	10	0			
	,, 2 Subscriptions 1884-5				0	10	0			
	,, 1 do 1885-86				0	5	0			
	,, 1 do 1886-87				0	5	0			
	,, 9 do 1882-83				2	5	0	33	15	0
	,, Receipts from Members for Printing							2	12	6
	,, Receipts from Sale of Transactions							0	5	7
								£37	19	4
1884 Sept.	By Balance brought down							2	7	5

Audited and found correct,

THOS. R. CONNELL, } Auditors.
JNO. R. WEBB, }

Liverpool, September 30th, 1884.

W. H. WALKER,

TREASURER.

LAWS

OF THE

LIVERPOOL GEOLOGICAL ASSOCIATION,

Established 3rd June, 1880.

RULES PASSED 15TH NOVEMBER, 1880.

OBJECT.

The object of the LIVERPOOL GEOLOGICAL ASSOCIATION *is to promote the study of Geology and its allied Sciences.*

RULES.

I.

That every Candidate for membership shall be proposed and seconded by two members of the Association, and balloted for at the next Ordinary meeting; and the consent of three-fourths of the members then present shall be necessary for the admission of such Candidate.

The proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

II.

Every member shall pay an annual subscription of Five Shillings, payable on the 1st October, or in the case of a new member, within one month after election. Any member not paying the subscription within three Calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

III.

The officers of the Association shall be a President, Vice-President, Treasurer, Secretary, and five other members, who together shall constitute the Council to manage and direct the affairs of the Association. Five to form a quorum. The officers shall be elected at the Annual Meeting, to be held in October; retiring officers shall be eligible for re-election. Any vacancy occurring during the year shall be filled up by the Council.

IV.

The Treasurer's Financial Statement shall be presented to the Association, with the Annual Report, after having been duly audited by two members proposed, seconded, and elected at the last meeting of the Session.

V.

The Ordinary Meetings shall be held on the first Monday in each month, at Eight o'clock in the evening. The order of proceeding at such meeting shall be :—

1.—The ordinary business of the Association.

2.—Miscellaneous Communications.

3.—Original Papers or Communications, to be followed by discussion thereon.

4.—Announcement of business for the next meeting.

VI.

A Special Meeting may be called at any time by the Council; and they shall be bound to call such a meeting on receipt of a requisition signed by not less than ten members, stating the purpose for which the meeting is to be convened. Seven days' notice of a Special Meeting shall be given to every member, such notice to specify the business to be considered, and the meeting shall be held within twenty-one days after the receipt of the requisition. No other business shall be considered at a Special Meeting except that for which it has been called.

VII.

Field Meetings shall be held at places of Geological interest, but none of the private business of the Association shall be transacted on such occasions.

VIII.

The votes on any question brought before the Association shall be taken by a show of hands, except those for the election of officers and new members, which shall be taken by ballot.

IX.

The manuscript of every Paper read, or a clear and legible copy thereof, written on foolscap, shall become the property of the Association, and shall be placed in the Library for the use of the members.

X.

In case of non-compliance with the Rules of the Association, or misconduct by any member, such member may be requested by the Council to resign. Failing to do so, the Council may bring the case before a meeting of the Association which shall deal with it as may seem expedient.

XI.

Every member may introduce a friend at any Ordinary or Field Meeting of the Association, provided, however, that no person qualified to become a member be admitted as a Visitor more than twice in the same year.

XII.

No addition to, or change in these Rules shall be made except by a majority of not less than two-thirds of the members present at a Special Meeting to be convened for that purpose.

LIVERPOOL GEOLOGICAL ASSOCIATION.

FORM A.

M ....

....

being desirous of admission to the Association, We, the undersigned, recommend h as a proper person to become a Member.

Dated........................18

Proposed by...

Seconded by ....

Date Proposed ....

Date Elected ....

Signature of Candidate ....

....Secretary

REGULATIONS FOR THE ADMISSION OF MEMBERS.

RULE 1—That every Candidate for membership shall be proposed and seconded by two members of the Association, and balloted for at the next ordinary meeting; and the consent of three-fourths of the members then present shall be necessary for the Admission of such Candidate.

The Proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

RULE 2—Every Member shall pay an annual Subscription of Five Shillings payable on the 1st October, or, in the case of a new member, within one month after election. Any member not paying the subscription within three calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association,

LIVERPOOL GEOLOGICAL ASSOCIATION.

LIST OF MEMBERS,

Session 1883-84.

Ashton, F. W	4, Richmond Terrace, Breck Road, Liverpool
Auden, Anthony W.	14, Aspen Grove, Lodge Lane, Liverpool
Bramall, Henry, M. Inst., C.E. (President)	3, Balmoral Road, Elm Park, L'pool
Banister, H. C.	Rossett Road, Crosby
Barber, J. M.	4, Eyes St., Breckfield Road North, Liverpool
Baylis, J. Walter	56, Vine Street, Liverpool
Beasley, H. C.	Leam Cottage, Wavertree
Brennan, Thos.	30, Granton Road, Liverpool
Biram, Benj., Assoc. M. Inst. C.E.,	St. Helens, Lancashire
Biram, B. Swinton, B.A... ..	Sherdley, St. Helens
Broadfoot, Bruce M.	67, Huskisson Street, Liverpool
Broadhurst, Miss E.	Care of H. Broadhurst. 21, North John Street, Liverpool
Broadhurst, Miss M. A.	Care of H. Broadhurst, 21, North John Street, Liverpool
Brodie, Alexander	202, Upper Parliament St., L'pool
Brodie, J. S., M.I.M.E... ..	Borough Engineer, Whitehaven
Browne, A. H.	31, James Street, Liverpool
Cade, Lawrence W.	15, Upper Parliament Street, L'pool
Capon, R. M., L.D.S.	114, Vine Street, Liverpool
Carter, C. W.	4, Springfield, Everton, Liverpool
Clague, Daniel, (Member of Council)	81, Lime Grove, Lodge Lane, L'pool
Clarke, F. C.	47, Bickerton Street, Liverpool
Conlon, Bernard	22, Mount Pleasant, Liverpool
Connell, T. R.	Melville Chambers, Lord Street, Liverpool
Cooper, W. R., B.A.	11, Northumberland Terrace, Everton
Cotter, Mrs. B.	10, Oxford Road, Waterloo
Currie, Luke	3, Lord Street, Liverpool
Davies, David	Care of Messrs. Cochran & Co., Woodside Iron Works, Dudley
Deuchar, P. B.	17, Kingsley Road, Liverpool
Dickson, Edmund..	West Cliff, Preston
Downie, George	19, Oakfield Street, Liverpool
Duff, Samuel	55, St. Martin's Cottage, Ashfield Street, Liverpool

Dunsford, A. J.	Wynch House, Seacombe, Cheshire
Edwards, George H.	2, Whitechapel, Liverpool
Evans, E.	35, Beresford Road, Toxteth Park, Liverpool
Evans, J. C.	37, Ranelagh Street, Liverpool
Evans, J. G.	Brunswick Dock, Liverpool
Elias, O. H.	Mere House, Mere Lane, Everton
Fraser, John	1, Railway Cottages, Spekeland Rd, Liverpool
Findlow, John	42, Percy Street, Liverpool
Finlay, B. F.	Slater Court, Castle Street, L'pool
Fowler, Thomas Richard.. ..	139, Crown Street, Liverpool
Fox, Herbert, (Secretary) ..	18, Hackin's Hey, Liverpool
Gasking, Rev. Samuel, B.A, F.G.S.	11, Russell Road, Garston
Gray, G. Watson	12, Argyle Road, Garston
George, Isaac E., (Member of Council)	89, Beaconsfield Street, Liverpool
Gregson, G. E.	11, Chapel Street, Preston
Grisewood, W.	Liscard Park, Liscard. Cheshire
Hall, Henry; H.M. Inspector of Mines,	Rainhill
Hall, Hugh F., F.G.S.	Greenheys, Grove Road, Wallasey, Cheshire
Hancox, John	101, Prescot Street, Liverpool
Hedley, J. L., H.M. Inspector of Mines,	The Gables, Flooker's Brook, Chester
Henson, Samuel	227, Strand, London, W.C.
Hewitt, William, B.Sc.	21, Verulam Street, Liverpool
Hills, William	Fountain Street, Higher Tranmere, Cheshire
Holbrook, The Hon. Henry ..	Parkgate, near Chester
Houlding, John	34, Tynemouth Street, Liverpool
Hunt, T. S.	9, Wordsworth Street, Liverpool
James, Raoul	309, Upper Parliament St., L'pool
Jeffs, Osmund W...	8, Queen's Road, Rock Ferry.
Johnson, T. M.	60, Lord Street, Liverpool
Johnston, W. H.	11, Chapel Street, Preston
Jones, J. C.	82, Windsor Street, Liverpool
Jones, J. D.	72, Harrowby Street, Liverpool
Jones, R. T.	32, Canning Street, Liverpool
Jones, W. A.	32, Laurel Road, Edge Lane, L'pool
Jones, W. Joinson..	7, Rhiwlas Street, Liverpool
Keyte, T. S., C.E..	19, Chatham Place, Liverpool
Kirkmann, H.	Oswell Bank, Seaview Rd., Liscard, Cheshire
Kissack, J. M.	18, Newland Street, Everton, L'pool
Labouchere, J. M.	106, Spencer Street, Liverpool
Lawrenson, F. J.	131, Walton Village, Walton

Lewis, A. E.	74, Rogerson's Quay, Dublin
Lewis, George	81, Everton Terrace, Liverpool
Lister, R. F.	8, Ashfield, Wavertree, Liverpool
Littlewood, T.	40, High Street, Woolton
Logeman, Willem S., Lit Hum. Cand., M.R.C.P.	Newton School, Rock Ferry, Cheshire
Maguire, T.	108, Landseer Road, Liverpool
Mannington, C E.	40, Rumney Road, Kirkdale, L'pool
Mannington, H. T. (*Member of Council*)	40, Rumney Road, Kirkdale, L'pool
Marrat, Frederick P.	21, Kinglake Street, Liverpool
Marrow, Fred.	20, Boundary Street, Liverpool
Marrow, P. H	28, Humber Street, Liverpool
Martin, William	14, Normanby Street, Liverpool
McMillan, R.	34, Salisbury Street, Liverpool
Miles, Charles E., (*Vice-President*)	57, Willow Bank Rd, Higher Tranmere, Cheshire
Miles, W. H.	3, Clifton Crescent, Birkenhead
Moore, C. Clifton, Junr... ..	125, Chester Rd, Hartford, Northwich
Moore, Miss Emily	48, Eastbourne Street, Liverpool
Moore, T. J., C.M.Z.S.	The Museum, William Brown St. Liverpool
Morgan, C. H.	72, Bank Road, Bootle
Morgan, James	City Engineer's Office. Dale Street, Liverpool
Morris, John, (*Member of Council*)	40, Wellesley Road, Liverpool
Morris, Mrs. John	40 Wellesley Road, Liverpool
Narramore, W.	5, Geneva Road, Elm Park, L'pool
Nicholls, John	11, Chatham Place, Liverpool
Owen, William	4, Comus Street, Liverpool
Owens, Philip	66, Orient Street, Liverpool
Padley, F...	15. Church Street, Liverpool
Pain. C. Squarey..	14, North John Street, Liverpool
Paton, Rev. Wm., M.A... ..	Mossgiel House, New Ferry, Cheshire
Potter, Charles	101, Miles Street, Liverpool
Plastow, James	169, Great Homer Street, L'pool
Pratt, Miss E.	15, Alt Street, Liverpool
Pritchard, D. D...	10, Lothair Road, Anfield
Quilliam, W. H...	49, Rufford Road, Liverpool
Reade T. Mellard, C.E. F.G.S.. F.R.I.B.A.	Park Corner, Blundellsands, Lancashire
Ricketts, Charles. M.D. F.G.S..	22, Argyle Street, Birkenhead
Roberts, Isaac, F.G.S.	Kennessee, Maghull
Roberts. J. Meredydd	20, Lowther Street, Liverpool
Roberts, Robert	9, Northumberland Terrace, L'pool
Robins, G. J.	Ashton Cross, Newton-le-Willows

Robson. George	66, Roscoe Street, Liverpool
Robson, Mrs.	17, Nile Street, Liverpool
Rogers, James E. A.	7, Oak Terrace Beech Road, Fairfield, Liverpool
Ross, Alex., M. Inst. C.E. ..	L. & N. W. Ry., Edge Hill, L'pool
Rowe, Edmund..	23, Frodsham St, Tranmere, Cheshire
Rowett, Charles	2, Verulam Street, Liverpool
Rowlands, T. V...	89, Duke Street, Liverpool
Rundell, T. W.	Litherland Park, Liverpool
Sharpe, Granville H., F.C.S. ..	Batavia Buildings, Hackin's Hey, Liverpool
Sharpe, R. A.	5, Welbeck Terrace, Birkdale, Southport
Small, Laurence	1, Rutland, Street, Everton, L'pool
Shilston, Capt. H. P.	1, Saltoun Terrace, Seacombe
Shilston, Mrs. H. P.	1, Saltoun Terrace, Seacombe
Shilston, Thomas, M.I.N.A. ..	31, Westmoreland Road, Newcastle-on Tyne
Shilston, Mrs. Thomas ..	31, Westmoreland Road, Newcastle-on-Tyne
Simpson, L. C...	Falkland Road, Egremont, Cheshire
Smith, Edward	15. Upper Parliament Street, L'pool
Storey, John	27, Gibson Street, Liverpool
Tapscott, R. L...	41, Parkfield Road, Liverpool
Tate, A. Norman, F.I.C. ..	9, Hackins Hey, Liverpool
Tate, George, Ph.D. F.G,S. ..	College of Chemistry, 96, Duke Street Liverpool
Tate, John A.	27, Chesnut Grove, Marsh Lane, Liverpool
Tildesley, H. F..	121, Queen's Road, Liverpool
Thomas, Hopkin	4, Cable Street, Liverpool
Walker, William H. (Hon. Treasurer)	40, Castle Street, Liverpool
Walsh, Peter H, F.C.S. ..	41, Russell Street, Liverpool
Ward, Thomas..	Northwich, Cheshire
Webb, John R. (Member of Council)	29, Fountain Street, Higher Tranmere
Westcott, H.	94, Prince's Road, Liverpool
Wigzell, Miss M.	22, Russian Drive, Tue Brook, Liverpool
Williams, J. J..	3, Ducie Street, Liverpool
Williams, J. M.	The Hawthorns, Hawthorn Road, Bootle
Williams, Miss L.	Hill Top, Bradfield, near Sheffield
Williams, T. G.	Moss Bank, Croxteth Road, Liverpool
Williams, T. H.	2, Chapel Walks, Liverpool
Wright, W.	41, Langham Street, Walton
Young, Henry..	12, South Castle Street, Liverpool

ABSTRACT OF PROCEEDINGS

OF THE

LIVERPOOL GEOLOGICAL ASSOCIATION.

SESSION 1884-5.

OCTOBER 6TH, 1884.

The Annual Meeting was held on this date, at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President, in the chair.

The following were proposed as Members:—Messrs Arthur H. Dudley, Herbert Robson, B. Sc., and William Schweitzer.

DONATION TO THE LIBRARY.—Proceedings of the Astronomical Society, Vol. 2, 1883-4, from the Society.

During the evening a number of interesting objects were exhibited, including microscopic sections of rocks and minerals, by Messrs. G. W. Gray, D. Clague, and R. W. Manning; mineral specimens, by Messrs. C. E. Miles and H. Fox; rock specimens and fossils, by Mr. T. S. Keyte; group of fossils, arranged side by side with their recent representatives, by Mr. D. Clague; and geological sections and drawings, by Mr. P. Owen.

THE REPORT for the past Session having been read and adopted, and the Officers for the coming Session elected, the President proceeded to deliver his Address, of which the following is an abstract, on

PRACTICAL FIELD GEOLOGY.

THE remarks on this subject will be very elementary, and are addressed to and intended chiefly for the benefit of the younger and less experienced members of the Association, who may have felt some little difficulty in practically applying the knowledge they have gathered from books. We may assume that every young geologist will have read some recognised manual or text-book, such as Lyell's, Juke's, or Geikie's, or De la Beche's *Geological Observer*, and become familiar with the terms and leading principles of the science; and it is very desirable that he should have some practical acquaintance with the rocks of most usual occurrence, at least so far as such acquaintance can be gained from hand specimens. He will desire now to go into the field and apply his knowledge to the examination of the structure of some special district in which he is interested, and will wish to record the result of his observations in the form probably of a geological map and sections.

Now do not suppose that to do this requires any very elaborate outfit. The absolute essentials are not many, and need not be costly; indeed, the simpler, fewer, and lighter the impedimenta one has to carry, the better will one be able to bear the heat and burthen of a long summer day spent in the field.

The first and most essential requisite is a correct topographical map, without which no accurate or valuable work can be accomplished. Incorrectness in the map may give rise to distortion of the geological features, and erroneous deductions from the observations recorded. In this country we

have the Ordnance Survey maps on the scales of one inch and (for some counties) six inches to the mile, the latter having *contour* * lines, which will be found of great service. Besides the map, the geologist will require a

Compass, one about 2 ins. diameter, which may be carried in the waistcoat pocket, and will cost about 5s., will answer for most purposes.

Clinometer, which may be easily made at a cost of a few pence, by taking a strip of wood 6 ins. by 2¼ ins., attaching to one edge a pendulum with a pointed lower end, and graduating the arc described by the point, either on the wood or on a strip of paper pasted upon it. A similar strip of wood may be hinged to it at one end, so as to fold over and protect the pendulum from injury. The compass and clinometer may be had combined in one very portable instrument, but the cost is considerable. A very convenient form is made by Baker, High Holborn, with sights and 2¾ in. compass, at 17s. 6d.

Protractor, of boxwood, of the usual oblong form, serving also as a scale and ruler; cost about 1s.

Pocket Lens—say one shilling to half-a-crown—and

Note-book, which is most convenient if oblong, and about 6 ins. by 4 ins.

Hammer, the head of which may be about 4¾ ins. long, with one face about ⅞ in. square, the opposite end being chisel-shaped, with the edge either at right angles to or in a line with the shaft, which may be 11 ins. long. This is conveniently carried in a loop of stout tape or braid, sewn to the waistcoat on the left hand side.

A small measuring tape will also be of great service.

Thus equipped, the geologist may proceed to the field, and it will be advisable first to make a preliminary traverse of the ground, in doing which the following rules may be usefully remembered:—

* A *contour* is a line passing through those points on the earth's surface which lie in the same horizontal plane. Those on the six-inch maps are at elevations of each twenty-five feet above sea level. A new series of the one-inch maps is in course of publication, in outline and with contours. Contours answer admirably for hill shading, for which in America they are much used.

1. If the beds are level, the outcrops will correspond with the contour lines, and the highest beds will be the newest.
2. If the beds dip towards the hill, the lines of outcrop will be straighter than the contours, and in ascending a valley the newer beds will be the highest.
3. If the beds dip from the hill, the lines of outcrop will be more winding than the contours, and,
   (a) if the valley is steeper than the dip of the beds, the newest beds will be furthest up the valley; but
   (b) if the valley is less steep than the dip of the beds, then the older beds will be highest up the valley.

Selecting now some important, persistent, or easily identified bed or junction, he will proceed to trace out and map the outcrop.* He will search for any opening, ditch, road cutting, quarry, well, or other section. Each such section he will examine, fixing and marking its position on his map, for which purpose he will find his compass very useful, either by taking a bearing to some well-defined object, such as a building, and measuring the distance; or by taking bearings to two such objects, and laying them on the map,—when the point of their intersection will be the point sought. Having fixed the position and noted it, he will take the compass bearing of the direction of the dip and its amount, marking them on the map, and also entering them in his note-book, together with a full description of the nature of the rock (using the hammer freely to chip through the weathered surfaces) and fossils (if any), and every other particular obtainable, with sketches of the appearances presented. He will carefully examine the whole ground in this manner, step by step, collecting all the information available, and then by collating his notes, he will be able with more or less accuracy

* The line of outcrop of any bed is the line where the highest part of such bed appears at the surface, from beneath any superincumbent stratum.

to define the limits occupied by each bed or formation; in fine, he will have a geological map.*

It is not always easy to get the correct direction of the line of dip. If the surface of the bed is exposed, a little water poured upon it will indicate the dip by the line of its flow. In beds appearing in the face of a cliff, by standing a little distance away and bringing the edge of the clinometer between the eye and the line of a bed, the amount of dip may be obtained with considerable accuracy. In many cases it will be necessary to observe the apparent dip in two directions, from which find the true direction of the dip by the following (known as Penning's) rules:—

CASE 1.—*Where the observed dips incline from or towards the angle formed by their directions. Fig.* 1.

RULE.—From *a* (fig. 2) draw *a b*, *a c*, in the directions of the observed dips, making the length of *a b* equal to the number of degrees of dip in *a c;* and *a c* equal to the number of degrees of dip in *a b*. Join *b c;* this is the line of strike. From *a* draw *a d* at right angles to *b c*. Then *a d* is the line of true dip.†

CASE 2.—*Where the observed dips incline one towards and the other from the point of intersection. Fig.* 3.

RULE.—Prolong one line as shown dotted in fig. 3, and then proceed as in the preceding case.

To find the amount of true dip.—On the line *a c* (fig. 2) set out at *a* the angle of dip a, and draw *c e* at right angles to *a c*. On the line *d b* set out *d f* equal to *e c*. Join *f a*. Then the angle *f a d* is the angle of true dip.

Dalton's rule to find direction and amount of true dip.—From *a* (fig. 4) set out the directions of the observed dips *a b*, *a c*. From *a* draw *a d* at right angles to *a b;* also *a e* at right angles

* In coloring the map, it is advisable to adhere to the colors adopted by the Geological Survey. An index to these colors is published (price 5s.), which is also a useful table of all known British strata, and has a number of abbreviations and signs which will be found to save time and space in the note-book and map.

† This rule is not strictly correct, the angle being taken as equivalent to its tangent. For small dips it is sufficiently near for all practical purposes. For angles of over 30, Dalton's rule is preferable. For further consideration of graphic methods, see *Geological Magazine*, 1884, pp. 154 and 412.

to *a c*, and equal to *a d*. Draw *d b*, *e c*, making the angles *a c e*, *a b d*, equal to the respective angles of dip. Join *b c*. From *a* draw *a f* at right angles to *b c;* also *a g* at right angles to *a f;* and make *a g* equal to *a d*. Join *g f*. Then *a f* is the direction of the true dip, and the angle *a f g* is its amount.

The information conveyed by a geological map is rendered much more complete by a well-considered series of illustrative sections, the preparation of which may now be briefly considered. It is equally essential, as in the case of a map, that the geologist should have a correct topographical outline whereon to record his results, and this ought to be on the same vertical and horizontal scale. If the map has contour lines marked on it, a section may often be constructed with sufficient accuracy from those lines, the intermediate parts being sketched in by the eye on the ground. Or if only the principal heights are given, these may be connected by a traverse run by means of the aneroid; or a line may be run altogether by this instrument. In most mining and engineering operations, however, complete accuracy is necessary, and it then becomes essential that the section line shall be run by the theodolite or spirit level.

In choosing the most suitable line of section to illustrate the geological structure of a district, it is best, wherever possible, to select a line to coincide with the line of dip; but this cannot always be done, and when the line does not so coincide a correction of dip must be made, so as to obtain the dip on the line of section, for which purpose use the following method:—

When a line of section crosses beds obliquely with the line of dip or strike, to find the angle of apparent dip on the line of section.—From *a* (fig. 5) draw *a b* in the direction of the strike, and *a c* in the direction of the line of section. From *b* draw *b c* at right angles to *a b;* *b c* is the line of true dip. From *c* draw *c d* at right angles to *b c*, and make the angle *c b d* equal to the angle of dip. From *c* draw *c e* at right angles to *a c*, and equal to *c d*. Join *a e*. Then the angle *c a e* is the angle of apparent dip on the line of section.

The geological details of the section, outcrops, &c., will be obtained from the already constructed geological map and the note-book, and supplemented by such further details as can be gathered from an examination of the ground with the partially completed section in hand. The appearance presented by such a first section is shewn in fig. 6, and the outline as seen on the surface being filled in as completely as may be, the inductive powers of the geologist will be exercised in carrying out the details of structure underground, and unravelling the complexities which faults or other disturbing influences may have introduced.

In conclusion, the speaker urged the great importance of care and rigid accuracy in making and recording observations, and the necessity of clearly distinguishing in the note-book facts which are the result of personal examination, from hypotheses, or information received from some other source.

During the address, the speaker shewed the methods of tracing an outcrop on the ground; making and recording observations of quarries, road sections, &c., and collating these on the map; ascertaining and noting positions and dips by aid of compass and clinometer; constructing sections by contours, aneroid, &c., and filling in geological information on same; working out the various problems and illustrations with the instruments exhibited, and on the black board.

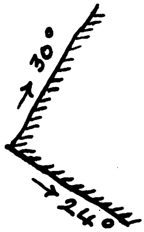

Fig. 1.

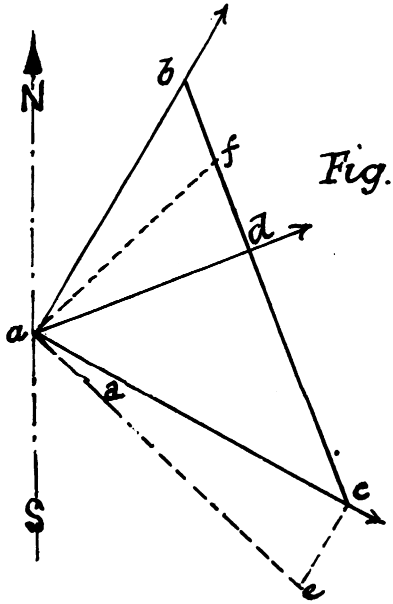

Fig. 2.

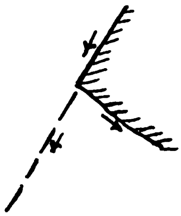
Fig. 3.

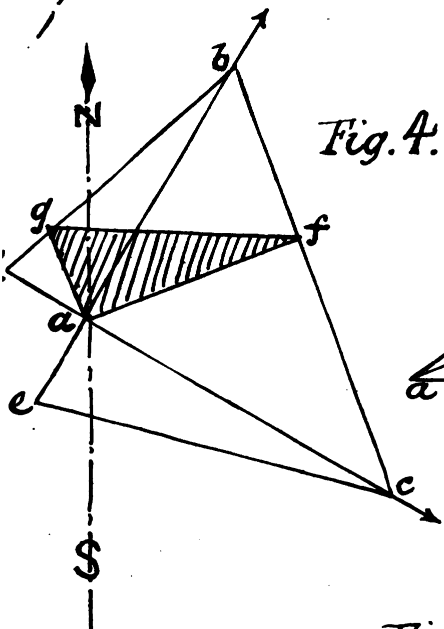

Fig. 4.

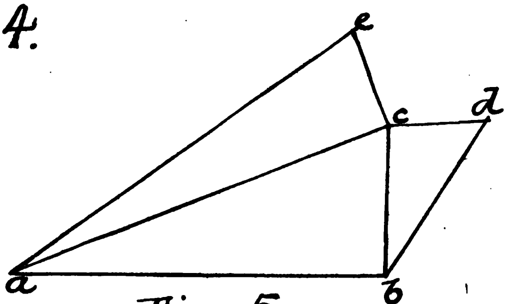

Fig. 5.

Fig. 6.

LIVERPOOL GEOLOGICAL ASSOCIATION.

NOVEMBER 1ST, 1884.

The members of the Association visited the Royal Institution, Colquitt Street, and inspected the collection of minerals in that building.

NOVEMBER 3RD, 1884.

At the ordinary meeting, held on this date in the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President, in the chair, the following were elected as members :—Messrs. Arthur Dudley, Herbert Robson, B. Sc., and William Schweitzer.

DONATIONS.

Report of the Smithsonian Institute, 1882; Proceedings of the Liverpool Geological Society, 1883–4; "On the Colœptera of Liverpool District," by J. W. Ellis; "On a Section of Keuper Marl at Great Crosby," by T. Mellard Reade, F.G.S.; "On the Pre-Cambrian Rocks of Pembrokeshire," by Dr. H. Hicks, F.G.S. *These were presented by the respective authors and societies.*

Abstract of a Paper read by Mr. J. R. WEBB, on

"THE FOSSIL REMAINS OF MAN."

THE fossil remains of man include not alone his bones, but also the implements he used, and these latter are the most frequently discovered, if not the most important, evidences of his pre-historic existence. We find them in the fluviatile gravels of Western Europe, India, Palestine, and America; in limestone caverns, peat-mosses, and the silt of lakes in

various parts of Europe, notably France, Belgium, Denmark, and Switzerland, and in our own Islands.

The implements have been arranged according to their geological position, and the degree of culture they indicate on the part of their makers. There are articles of stone, bone, horn, and bronze, but the stone and bronze predominate and determine the class. We have thus a stone age and a bronze age, and it is found the use of stone preceded that of bronze. The period during which stone was exclusively used has been divided into two sections,—a Paleolithic or old stone, and a Neolithic or new stone age. The divisions, stone and bronze, agree with an old Greek tradition preserved in Hesiod's poems, and this may be taken as valuable external evidence of the truth of opinions arrived at independently from scientific observation.

The Paleolithic fossils justify their name by the rude appearance they present, and their association with the bones of extinct mammalia, such as the mammoth, rhinoceras, cave bear, lion, hyæna, with many others.

Our evidences of Paleolithic man are mainly gleaned from the river gravels of England and France, and the limestone caverns of Western Europe. In England the most important deposit of this age occurs in Kent's Cavern, near Torquay. The cave consists of two parallel series of chambers, which pierce the Devonian limestone at an altitude of 180 to 190 feet above mean tide level, and about 70 feet above the adjacent valley. The implements (flints) are found in red cave earth, which underlies stalagmite of varying thickness, and rests on a dark red calcareous breccia. The flints are of three types—the lanceolate, oval, and flake—and with them were found bone harpoons and an awl. Below in the breccia a flint implement of somewhat ruder character was found associated with bear's canines, which had become completely mineralized; one of the bear's canines was found by Professor Boyd Dawkins, in the overlying red earth, converted into an implement with cutting edge, thus testifying to the lengthened stay of man in the district.

Though now generally accepted as of human origin, the discovery of these human relics failed, for many years, to excite that attention which their importance, in the light of later discoveries, would seem to demand. It was not till long after M. B. de Perthes gave to the world the result of his researches at Abbeville, to be after referred to, that the Kent's Cavern deposits received their due attention.

The animal remains from Kent's Cavern include the mammoth, Irish elk, horse, hyæna, and machairodus. All are found in the red earth with the flints.

Subsequent to the discoveries made in Kent's Hole, the now celebrated and important series of flint implements, &c., from the valleys of the Somme, Thames, Ouse, and Waveney, and the caves of the Perigord district, were brought to light.

The light thrown on the questions of primeval civilization and the antiquity of man in Europe, by means of the articles found in these various places, can scarcely be over-estimated. They certainly show him to have been living in England and France at the close of the Glacial Period, and at that time he was a savage obtaining a precarious living as a hunter, clad in skins, and seeking shelter in holes in the hill sides, where he held rude feasts, and has left the refuse of his meals for our instruction. Destitute of almost all the necessaries of life, wanting even the companionship of the dog, exposed to long and rigorous winters, and surrounded by many and fierce enemies, his lot must have been peculiarly wretched; yet, it is interesting to note, these Paleolithic hunters, like the Eskimos and Australians of later days, cultivated the fine arts, and have left us many spirited sketches of the animals they lived amongst and contended with in that strange old home of theirs. Of these, the most celebrated is the etching, on ivory, of the mammoth from La Madeleine, which is of especial value as proving man's co-existence with that animal.

As the most important discoveries of Paleolithic man have been made in the Somme Valley and Perigord caves, a short reference will not be out of place.

At various heights on the sides of the Somme Valley occur patches of gravel, remains of old terraces resting on the chalk, the predominant formation in the district. From 18 to 25 or 30 feet below the surface of the terraces, the flint implements of Abbeville and St. Acheul are found in great abundance associated with the remains of extinct mammalia, in such a manner as to leave no doubt of their contemporaneous character. Interesting proofs of glacial conditions are found in these terraces,—such as blocks of sandstone three or four feet in diameter, which no river like the Somme could have moved; while in other places the drift is contorted in a manner similar to that observed at Cromer and elsewhere,—a condition generally ascribed to ice action. Some idea of the antiquity of these deposits may be gathered from the fact that a mass of gravel and peat, varying from 24 to 44 feet in thickness, has accumulated and grown since the latest of the terraces was formed. Roman dishes were found at a slight depth from the surface, and their position has been used to calculate the age of the whole formation. Supposing the growth of peat to have proceeded at the same rate before the Roman period as since, some 30 to 40,000 years have elapsed since the peat first commenced to grow.

Space does not permit of more than a reference to the caves of the Perigord district. They have yielded a rich and varied assortment of articles in flint, horn, ivory, and bone, and from them have been obtained the remarkable etchings before referred to. The animal remains confirm the opinions as to glacial conditions gathered from the drift deposits, while the implements are of similarly rude character.

From the evidence obtained, we are convinced that Paleolithic man was a savage, and that he saw the close of the Glacial Period, if he did not indeed make his first appearance before that close.

When we pass from the consideration of the Paleolithic fossils to the Neolithic, a great difference is at once apparent. The articles of human origin betray greater care and finish in their shape and adaptation to human needs, so much so

that one is compelled to believe in either a great break in time, or the introduction of a new race on the stage of man's progress. Probably both conditions combined to produce the results brought to light in the lake villages of Switzerland and the burial caves of Western Europe. An intermediate stage in culture certainly is found in the relics from the Danish kitchen middens, which is some proof that orderly progress has been the rule in human affairs. Another very important difference between the two periods is the almost complete change in the character of the associated animals.

With the Paleolithic flints we have such strange forms as mammoth, hyæna, rhinoceras, &c.; but the Neolithic period brings with it animals familiar to us all, as the roe-deer, stag ox, sheep, pig, &c. Only two forms of mammalian life can be said with certainty to pass from the older to the newer age, the bos primigenius and the reindeer, which is living now in Northern Europe and America.

The kitchen middens referred to above are mounds of considerable size, occurring in some numbers on the eastern coast of Denmark. They contain flint articles, which though rude show strong signs of advance, being often ground and sharpened, and fragments of very rude pottery. The shells are of mollusca which at that period attained their full development in the Baltic, though now through changes in the land the water has become brackish, and such forms of life are only found dwarfed, or do not exist there. This fact gives evidence of considerable antiquity for the mounds.

Next to the mounds the richest deposits of Neolithic fossils occur in the mud of the Swiss lakes, and from these a very varied suite has been obtained. Indeed the lake dwellings existed down into the historic period, apparently without break in the continuity of human progress in this district. It is interesting to note that in the villages of stone as contrasted with those of bronze age—for both are found—a marked difference in the numbers of bones of wild and domestic animals is observed. In the former the wild forms predominate, whereas in the latter it is the domestic races

which have left most traces. Another interesting feature of these lake village deposits is the presence of grains of wheat, showing conclusively that agriculture had developed itself in Western Europe. The oldest traces of agriculture in Europe are found in the stone age villages of Switzerland.

Attempts have been made to calculate the age of these human relics, by M. Morlot and others, from which it has been estimated that the Neolithic period goes back for some 6,000 or 7,000 years, the bronze 3,000 or 4,000. Such calculations are interesting, but should not be accepted as conclusive.

It is from the Neolithic deposits that the most certain traces of man, his own bones, are obtained. It is true skeletons of man have been found in caves under circumstances that have led eminent observers to pronounce them Paleolithic, but their opinions have been opposed by others, and we cannot assume with certainty that any bone of Paleolithic man exists. With Neolithic man the case is different. We have many of his bones found in different caves, and no doubt exists as to their true age. They are especially interesting as indications of the various races which formerly inhabited Europe, and many ingenious speculations have been made as to the race movements of the tribes of which these old skulls and other bones are the present representatives. Of all the human skeletons discovered, that from Neanderthal has, perhaps, excited most controversy; and if we cannot admit its extraordinary conformation to be a direct link between man and the apes, it may be accepted as an indirect one—a case of reversion to a lost type which was in many respects ape-like.

The course of research into the history of primeval man has not, so far, solved the mystery of his origin. With one solitary exception he was as human at the close of the Glacial Period as he is now. Must we look for the first connecting links with the brute in the Miocene or Eocene Periods, or shall we ever find them?

LIVERPOOL GEOLOGICAL ASSOCIATION.

DECEMBER 1st, 1884.

At the ordinary meeting, held this date at the Free Library, Mr. H. Bramall, M. Inst. C.E., President, in the chair, the following were proposed as members :—Messrs. Joseph Brown, 37, Exe-street, Liverpool; C. R. Bellamy, Cecil Villa, Liscard; and R. S. New, 47, North John-street, Liverpool.

DONATIONS.

Transactions of the Manchester Geological Society, parts 1 and 2; Journal of the Liverpool Astronomical Society, vol.iii., part I. *Presented by the respective societies.*

The President announced that the Council had appointed Mr. W. H. Miles Librarian for the ensuing year.

The following paper was then read by Mr. D. Clague.

"NOTES ON THE ASCENT OF MOUNT FRANKLIN, NEW ZEALAND."

(The substance of the following communication is taken from a paper read at the Philosophical Society of Nelson, N.Z., by Mr. James Park.)

A few months ago we were favoured with a very excellent paper by our President, on the Mineral Resources of New Zealand, which created such interest in that far-off land, that when recently news came that a party of scientists had succeeded in scaling a mountain there, that had hitherto been untrodden by the white man's foot, we were prepared to welcome the message as one in which we were concerned.

Mount Franklin is the culminating point of the Spencer and St. Arnaud range of mountains in the northern part of the South Island, and is marked on the maps as 10,000 feet in height, but as it had not hitherto been climbed, this altitude was only guessed at, as will be apparent further on.

On the 10th of March last they left Nelson, and spent six days in reaching the foot of the mountain; although these days were not spent in exploring the unknown region, their observations during this time were of such a character that they ought not to be overlooked.

In climbing the highlands which flank the mountain, it was noted that the bush line, or line at which the bush ceases to grow, was clearly marked on the mountain side, and that line is 4500 feet above the sea level, a fact useful to tourists in that district for estimating the heights of mountains around them.

One part of their journey was somewhat dangerous, and I cannot do better than let Mr. J. Park describe it in his own words. "At the end of the open flats we continued along high terraces, ascending and descending from terrace to terrace by steep side cuttings. After having travelled some hours, we crossed a large slip that comes down from the mountain above. As the slip is continually on the move all traces of the road have been obliterated, and it was not without considerable danger that horses could be got across, indeed a false step, and they would be precipitated into the river some 40 feet below; but this was not the only risk: the slip is fed from the mountains above, and there is therefore the danger of falling rocks always impending, and it was not without uneasy glances upward that we hurried across."

Passing on, the party reached the River Rainbow, an important tributary of the River Wairau. Their first acquaintance with this river was to see it flowing gently through finely grassed flats and terraces, suitable for pastoral purposes. Near the meeting of the waters they came upon the evidence of glaciers having once ploughed down the valley, traces of the moraine being still left, though the greater part of it has been

swept away by the river. Soon a grander scene burst upon their vision: at the end of the Rainbow Valley the mountains on either side seemed to meet and bar all further progress; on getting near to the barrier however, a narrow flat was found on the river side, and along this the party proceeded; in some places the flat was washed away, and the track was cut out of the solid rock, in some places being half tunnelled to obtain a few feet on the solid. "We had now," Mr. Park says, "fairly entered the Wairau Gorge. This is the most wonderful sight in New Zealand, even rivalling the dark canons of the Rockies, but to describe the massive grandeur of the scenery—how the castellated crags rise in rapid succession to the giddy heights of 3500 feet above the river on either side, darkly frowning upon the river as it dashes through its rock girt channel—would require the graphic pen of a Scott, or the inspired genius of a Dante."

On reaching an altitude of 5500 feet, a somewhat curious fact was noted, that in hollows on the mountain side were numerous little lakes or tarns, which are drained by the River Alma flowing down the flanks of the mountain, and that the River Wairau flows and cuts its way down between the two mountain ranges; closer examination showed that this double range of mountains had originally been an anticline, and that the river was flowing along the axis of the anticline, cutting its way into the very heart of the mountain, suggesting to us that mountain ranges, massive as they appear, the very backbone of a country, may yet be lines of weakness rather than of strength.

Returning from that elevation, a gorge had to be crossed, and the heights on the opposite side scaled. At length, seven days after starting, the party were at the foot of Mount Franklin, 4050 feet above the sea.

Mr. Park says, "for the first 1000 feet our progress through the tangled mass of low scrub was very slow and laborious; at length we reached a creek which opened out into an extensive basin-like valley, well grassed at its lower end, but presenting nothing but a great waste of bare rocks and shingle

at the upper end. After following the creek for about two miles, we left the main stream and scrambled up the steep face of an old terminal moraine, composed of a great wilderness of huge angular rocks piled one upon another in glorious confusion, to a height of 700 feet.

"On the opposite side of the valley we counted six or seven very distinct parallel terraces furrowed out by glacial action; of these, the highest three are continuous for some distance, but the others are frequently broken and interrupted, having been cut away by the creek when it ran at a higher level."

Mr. Park's account of these terraces reminds us strongly of the parallel roads of Glen Roy, and the various theories propounded to explain their origin, and we turn to Mr. Park's account to ascertain if there are any facts noted in that virgin land that will throw any light upon the subject, and when he describes Lake Tennyson being formed by the waters being held back by an old glacier moraine, it strikes us that in that fact we have suggested to us the probable character and origin of the parallel roads of Glen Roy, and the parallel terraces of the Wariau Valley; that they are shore lines formed by the waters of lakes when the water stood at those respective levels, the lakes themselves having been caused by the blocking up of the mouths of the valleys with moraine matter, and the alteration of the level having been caused by the waters cutting their way through the moraines.

Our travellers now passed away from the relics of glaciers to glaciers themselves, and here an incident occurred which was humorous, and might have been serious; again Mr. Parks must speak for himself. "By the aid of our alpenstocks we scrambled up the face of a snow field, when one of the party lost his footing and slid down the steep snow face at a terrible speed; by forcing his heels into the snow, and dragging his hands behind him he succeeded in guiding himself to some rocks projecting out of the snow, amongst these he landed fortunately, little the worse for his mishap. In honour of the gentleman whose fall caused no small alarm to the rest of the party, the glacier below was named the 'Curtis Glacier.'"

At the height of 5250 feet, the party came to the foot of a high rounded precipice covered with a mass of strong wiry snow grass, and by holding on to this grass they managed to climb upwards, when they reached a number of shingle slips which had to be traversed with great care. At the height of 6500 feet, a lake was seen at some distance to the west, estimated to be two miles long and half-a-mile wide, which they named Lake Thompson in honour of one of the party.

Snow fields had again to be crossed; in some places the snow was laid at such an angle that steps had to be cut in it for safety; then great masses of broken rock, angular and slab-like, of hard green sandstone, not weatherworn, but the fractures all fresh, sharp and angular, showing that they must have recently fallen; judging from the great quantity of newly fallen stones, and the quantity on the top broken and ready to fall, it was estimated that Mount Franklin is being reduced in height at least two feet every year. "Indeed," again to quote Mr. Parks, "we have geological evidence that this grand old mountain is but the ghost of its former self—truly a skeleton range with a narrow serrated backbone and razor-backed ribs."

Another peak was before them, another weary climb and the summit was reached, a little less than 8000 feet above the level of the sea. Little of the scenery could be taken in, for the whole country below them was enveloped in cloud; so erecting a cairn, they placed in it a tin box containing papers recording the date of the ascent and the names of the explorers; and then, with three cheers, they bade farewell to the lofty peak, and commenced their descent, the distant peaks responding to their cheers, not only by echoing back their voices but by other noises, the rumbling and crashing of rock masses (already loosened by the action of frost, now set free by the vibration of the air caused by those cheers), tumbling from rock to rock down to some lower ledge, where they would rest awhile.

The upper part of the mountain is composed of hard green and grey sandstones with interstratified shales, having a general westerly dip at angles ranging from 35° to 60°; the

sandstones, on account of their hardness, form the peaks, the shales more easily worn away form the river beds.

The lower part of the mountain is composed of chlorite schists and quartzites; gold has been found in the creeks below, which has probably been washed out of these quartzites.

The denudation which has already been referred to, not only has resulted in the accumulation of large angular fragments resting on ledges at the base of precipices, and in the shingle slips met with at intervals, which move down the mountain side like rivers of broken stone, but also in beds of water-borne gravel, sand and clay, which, in the lower reaches of the valley and in sheltered nooks on the side of the mountain, reach considerable extent and thickness, forming in some places alluvial plains.

Mr. F. P. Marrat described some interesting geological specimens recently acquired by the Museum Committee, illustrating his remarks by designs, and exhibiting some of the specimens.

LIVERPOOL GEOLOGICAL ASSOCIATION.

JANUARY 12TH, 1885.

At the ordinary meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst., C.E., President, in the chair, the following were elected as members:—Messrs. R. S. New, J. Brown, and C. R. Bellamy.

Mr. Charles Defieux, 98, Herschell Street, was proposed for membership.

DONATION.

Transactions of Manchester Geological Society, part 3. *Presented by the Society.*

COMMUNICATION.

Mr. I. E. George drew attention to a recent discovery of Tertiary Deposits of Crag Age in Cornwall.

A paper was then read by Mr. HERBERT FOX, on

TEN DAYS IN THE ENGLISH LAKE DISTRICT,

Illustrated by Lantern Views.

LIVERPOOL GEOLOGICAL ASSOCIATION.

MARCH 2ND, 1885.

At the ordinary meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President, in the chair,

Mr. C. Defieux was elected a member.

DONATIONS.

"Heroes of Science;" *presented by Mr. I. E. George.* Catalogue of Natural History Objects, exhibited by Lady Brassey; *presented by Mr. Bryce Wright.* Proceedings of Belfast Naturalists' Field Club, 1883-4; Annual Report of Liverpool Engineering Society, 1884; Proceedings of Geologist's Association of London, July, 1884; Journal of Liverpool Astronomical Society, Sept., Nov., Dec., 1884, and Jan., 1885; *presented by the respective Societies.*

A paper was then read by Mr. T. MELLARD READE, F.G.S., of which the following is an abstract, on

ARTISTIC GEOLOGY:

FFESTINIOG AND ITS NEIGHBOURHOOD.

In addition to its reputation for picturesque scenery, Ffestiniog is a very good centre for the geological student. Situated on a sort of promontory between two valleys, the Cynfael and the Dwyryd, at a sufficient elevation to maintain a bracing atmosphere, the mind and body retain that elasticity which makes mountain scenery so enjoyable; at the same time, those whose delight is the investigation of nature can fully gratify their cravings. I will proceed to describe some of the geological problems which force themselves upon the notice of the thoughtful mind.

The grand flank of Moelwyn, perhaps the finest mountain of its height I have ever seen, is to my mind of more interest than the much, if not over, praised vale. It can be seen at one view from base to summit. The river Dwyryd runs deep below you at the bottom of the vale, while Moelwyn rises from a tree-covered breastwork of hills in a great and serried scarp from Tan-y-bwlch to Blaenau Ffestiniog slate quarries. A descent from the village of Ffestiniog to the Dwyryd down a steep footwalk gives us some very picturesque views. We cross the river by a foot bridge, noticing, by the way, some well rounded boulders in the river bed. Ascending the other bank, we strike the main road which skirts a deep and picturesque ravine, thickly timbered. Arriving at the turnpike, we turn towards Tan-y-Grisiau, noticing a large bank of drift which lies near the fork of two streams. The road skirts one of these, in which are two very picturesque falls. The lower fall is crossed by a bridge just above it. Passing this, and ascending the right bank of the stream, we get a beautiful view of the upper fall. The rock here is part of a large mass of intrusive Syenite forming Moel Tan-y-Grisiau, and the stream has cut back a deep gorge into it. At the Tan-y-Grisiau station we begin the ascent of Moelwyn. Skirting the railway and ascending a footpath, we reach Llyn Trwsty-llon, a cwm lying under the great scarped face of Moelwyn. The rocks at the open part of the cwm slope towards the lake. The dip is 18° north-west. It appears to be striated south-east, but very faintly. The surface of the rock is much broken up in places since the glaciation. The cwm is a very perfect cup, broken through on the south-east side. From the summit of Moelwyn looking towards Snowdon, the immediate foreground is occupied with the remarkable mountain called Cynicht. From the road between Tan-y-Bwlch and Beddgelert it looks like a pyramid, but here it is seen in profile. It appears as a long ridge, its flanks scored with gullies and talus, which traverse its steep sides like streams, till they become confluent in the talus cones at the foot.

The traveller about Ffestiniog will soon find out, if he

carries a compass, that the general strike of the rocks is from south-west to north-east. At right angles to this the strata have been thrown into a series of anticlinal and synclinal folds, broken up, and, to some extent, obscured by faults. This feature can be observed on Moelwyn. A slate quarry on the back of the mountain shows the rock to dip rapidly to the north-west. Without going into details, the structure of the mountain is a series of shales and slates, with an interbedded massive series of felstones and felspathic ashes. It is in these hard massive beds which form the grand scarp in which lies Llyn Trwstyllon. The whole of these beds belong to the Lower Silurian series, commencing with the Lingula beds in the Ffestiniog and Tan-y-Bwlch valley, and terminating in the Bala beds at the summit of Cynicht. The slates of commerce are interbedded in the series, and as the beds dip steeply to the north-west, the quarrying operations have to be mostly followed by galleries, and not in great cuttings open to broad daylight, as is the case with the quarries at Penrhyn, near Bangor, which lie in the older Cambrian slates. To the north in the valley of Dolwyddelan, the calcareous ashes there largely developed are the actual representatives of the Bala limestone and Caradoc sandstone of Shropshire, and the vast masses of ashes that crown the felstones of Snowdon and Moel Hebog are but an enlarged development of the same strata.*

To understand the present surface form of the country, it is requisite to keep in mind the great fact that the whole of the Upper Silurian Strata, which formerly covered Merioneth and Carnarvonshire, has been entirely removed by denudation. It is only when we get as far to the south-east as the river Vyrnwy, where the great reservoir to supply Liverpool is being constructed, that we come upon the remains of the Upper Silurian, here preserved in a synclinal. A general glance at the geological map of North Wales shows the persistent strike of all the rocks from south-west to north-east. It is along these lines that the denudation has princi-

* Ramsey. "Memoir of the Geology of North Wales." 1st Ed.: p. 95.

pally acted, many of the main valleys possessing the same parallelism of direction. The hard beds of felstone and ash, and the intrusive greenstones and other igneous rocks, have helped to preserve that peaked and ridgy character which here gives the distinguishing beauty to the scenery.

At the entrance to Bwlch Cwm Orthin, a pass between Cynicht and Moelwyn, may be seen those well rounded rocks specially noted by Ramsey, as good instances of *roche moutonnee* glaciation. The cwm is a true rock basin, the dip of the strata to the north-west and the hardness of the felspathic rocks at the outlet, no doubt, being determining causes, together with ice, in producing this form of denudation. The stream from the Llyn Cwm Orthin has cut a narrow channel in the rock, about fifteen feet deep. It then falls about twenty feet down a nearly vertical joint plane. The peculiarity that attracts attention is the extraordinarily small influence the water has had in eating away the surface down which it falls, and the great effect it has had upon its more horizontal bed. This is a characteristic that may be observed elsewhere, at the Rhiadr Dhu, or Maentwrog falls for instance. It seems to point to the grinding action of stones, sand, and gravel, as the effective cause in the sawing down of a stream-bed, in hard rock, in a mountain district. These materials propelled along the bed of the stream would be always in contact with the rock, whereas at the fall they would be shot over, often without touching the vertical face. This subject of waterfall denudation is one that requires exploration. I am not aware of any geologist having specially investigated the subject.

Next to Moelwyn, the most prominent objects near Ffestiniog are the two Manods. A geological examination shows that they are in greater part carved out of massive felspathic porphyry, estimated by Ramsey at 1500 feet thick. This rock, as may be seen on a smaller scale, weathers into rounded forms, the Manods being, in fact, bossy hills formed by denudation from a bed of igneous rock, ejected during the deposition of the Llandeilo beds, upon the lower beds of which they

repose. These beds are altered by contact, whereas the slaty beds above are unaltered. (See Section p. 54, "Memoir of Geology of North Wales".) An instructive example of the rounded form into which this rock weathers may be seen in a hill near the slate quarry above Llyn Morwynion, from which lake the water supply of Ffestiniog is obtained.

Waterfalls are numerous and beautiful in the neighbourhood. The Falls of the Cynfael, within half a mile walk, are lovely in their variety. For a mile the stream may be followed through a series of glens, gullies and gorges, overhung and festooned with trees. The geological interest, as an example of denudation, is also great. About three miles from Ffestiniog, on the road to Bala, we get fine views of the Rhiadr Cwm, a series of splendid falls on the same stream, but quite different in character to those just described. It is a mountain torrent springing from rock to rock, and cutting deep gorges in the hillside.*

The road from Trawsfynydd to Bwlch drws Ardudwy, a wild pass in Merionethshire, traverses what may be considered the central dome of the Welsh system, forming originally the highest part of the mountain system of North Wales, but now stripped bare of its former covering of Silurian rocks both upper and lower, with its much altered Cambrian rocks deeply eaten into by denuding agencies, yet still presenting mountains rising 2400 feet above the sea level. These great mountains, the Rhinogs, Diphwys, &c., are entirely carved out of the Cambrian strata from base to summit, and many thousands of feet of overlying Silurian rocks have been entirely swept away by denudation.

* These falls have formed the subject of a fine painting by David Cox.

LIVERPOOL GEOLOGICAL ASSOCIATION.

MAY 4TH, 1885.

At the ordinary meeting, held this date at the Free Library, Mr. I. E. GEORGE in the chair,

Mr. H. L. Crate, Bromboro' Pool, was proposed for membership.

DONATIONS.

Annual Report of the Liverpool Free Library; *presented by the Committee.* Transactions of the Liverpool Engineering Society; Transactions of the Manchester Geological Society, parts 4, 5, 6 and 7; *presented by the respective Societies.* "Outlines of Field Geology," by Prof. A. Geikie; *presented by Mr. T. R. Connell.*

A paper, of which the following is an abstract, was read by Mr. C. E. Miles, on

MINERAL CRYSTALS AND THEIR PHENOMENA.

Hidden in the bosom of the earth are found great treasures of form and colour known as mineral crystals. From their symmetrical outlines and often rich display of colour they have very appropriately been termed the "flowers" of the mineral kingdom.

Naturally the great attractiveness of mineral crystals offers a strong inducement for inquiry into the laws which govern the formation and separation of such brilliant objects. The six plans or systems of crystallization to which all crystals may be referred reveal the wonderful constructive properties possessed and often developed by inanimate matter.

Crystals may be formed by various methods—sublimation, fusion, deposition from a liquid solution, and also by the less known method of crystallization of a solid from solution in a gas. Under the various conditions which crystals are found

in nature it may be readily inferred that different causes have been at work in their production. This may be gathered from the fact that certain minerals are usually found associated together in a more or less crystallized mass, whilst in other cases the minerals are found alone as single disunited crystals.

The fact that every chemical body has its own peculiar point of crystallization, not only enables us to realize how mineral bodies crystallize out from their menstrua upon that point being reached, but has an important bearing in relation to the arrangement of the structure of the crust of the earth. Without this law we should look in vain for mineral crystals beneath or upon the earth's surface.

It is very probable that according to the circumstances under which different mineral crystals have been formed, different electrical conditions have been set up in the crystals during their formation. This may perhaps be the reason of the phenomenon known as dimorphism, when a mineral is found crystallized in two separate crystallographic systems. Taking sulphur as an example, this substance can be crystallized in two different systems—in the Monoclinic system, by simple fusion of the sulphur and subsequent cooling at the ordinary temperature; and in the Rhombic system by fusion, and then a subsequent gradual cooling. Natural crystals of sulphur belong to the Rhombic system. Common salt or chloride of sodium, although not a dimorphous substance, developes modifications in its crystals according to the temperature at which they are formed. From the slow crystallization out of a cold solution the salt forms perfect cubes, whilst from a hot solution the cubes are joined into a beautiful aggregation of a hollow pyramidal character; this latter arrangement strongly suggesting the idea of polar forces having been at work to produce so wonderful a figure.

There were exhibited during the meeting a number of mineral crystals by Mr. Miles, in illustration of his paper; crystals of chlorate of potash by Mr. Mannington, illustrating polychroism; and models of crystals and axis skeleton by Mr. Clague,

LIVERPOOL GEOLOGICAL ASSOCIATION.

MAY 23RD, 1885.

The first Field Meeting of the season was held this day at Birkenhead, conducted by Dr. C. Ricketts, F.G.S.

At the railway cutting, Argyle Street South, in connection with the Mersey Railway, attention was drawn to the character of the glacial drift exposed—weathered boulders and shell fragments being seen in the red clay, with an almost entire absence of boulders in the overlying blue clay. Near Carlton Road were seen the relics of an old moraine containing angular fragments of local rocks, mixed with fragments of harder rocks common to the glacial drift.

WHIT-MONDAY, MAY 25TH, 1885.

A Field Meeting was held this day at Windermere and Ambleside. Wansfell Pike was ascended, and opportunities were gained for noting the erosive action of torrents on the limestone of its southern flank, and the weathering of the volcanic rocks near the summit of the mountain. The rocks belong to the Coniston series of Bala age.

JUNE 1ST, 1885.

At the ordinary meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President, in the chair,

The President announced that since the previous meeting Mr. Fox had resigned the office of Secretary, owing to pressure of business, and that the Council had appointed Mr. D. Clague to fill the post for the remainder of the session, and elected Mr. D. D. Pritchard to be member of the Council.

Mr. H. L. Crate was elected a member.

DONATIONS.

Transactions of the Burnley Literary and Scientific Society, vol. ii., 1884; Transactions of the Manchester Geological Society, parts 8 and 9; Proceedings of the Geologists' Association (London), Feb.–Oct., 1884; *presented by the respective Societies.*

EXHIBIT.

Mr. C. Potter exhibited some remains of Ox and Whale recently found by him in the Upper Scrobicularia Clay at Great Meols.

A paper (illustrated by specimens, and a series of water-colour enlargements of microscopic sections of minerals as seen with the polariscope) was read by Mr. I. E. George, on

ROCK FORMING MINERALS.

Some knowledge of the appearance and physical structure of rock-forming minerals is indispensable to the student of Geology, whatever special branch of the science he may wish to take up; and although it might appear a matter of congratulation that these minerals scarcely number a dozen, yet it may truly be said that any one who can readily identify, in all its conditions, even such a simple mineral as Quartz, is no mean Geologist.

Quartz, felspar, mica, hornblende, and augite are all common constituents of certain igneous rocks; and practice in determining these minerals may readily be had by the beginner from an examination of our granite walls, paving materials, and erratic boulders; whilst garnet, talc, and chlorite,—common metamorphic minerals,—may possibly be found by searching in local ballast heaps.

A great proportion, perhaps ninety-nine hundredths, of the stratified rocks of the earth have been derived from the disintegration of pre-existing igneous rocks; so that the constituents of a grit might be traced to the eroded quartz and felspar crystals of a certain granite, and the fine particles of a shale to the decomposed felspar and mica of the same rock.

The metamorphic series, sometimes very distinct from, at other times graduating into, the igneous, may also be reckoned as crystalline storehouses upon which the aqueous rocks have largely drawn for sedimentary material. The complete history of a rock-forming mineral, then, would involve its consideration under the three conditions of igneous, aqueous, and metamorphic; as it is found that a mineral may present very different external characters according to the group of rocks in which it is observed. The well-rounded grains of sand in a triassic sandstone bear little resemblance in form to the quartz crystals of a granite, or the sub-angular fragments of a millstone grit; but they may have been derived from either of these sources.

Quartz, which in its chemical composition is pure silica, will illustrate some of these features very well. In hand specimens this mineral may, as a rule, be recognised with ease by its superior hardness (refusing to yield to the point of a knife), conchoidal fracture, glassy lustre, and transparency. It is a common constituent of those igneous rocks which contain more than 70 per cent. of silica. Of granite, for instance, it is a necessary and constant factor along with felspar and mica. The proportion of silica in granite may be taken as 73 per cent., a considerable part of this being combined with alumina and potash to build up crystals of felspar, and a portion with alumina, potash and soda to form mica. It is only such silica as may not be required in the combinations with alumina, potash and soda, that takes the crystalline form of quartz, so that its presence to any considerable extent in an igneous rock always implies a high percentage of silica. Microscopically, quartz has very definite characters, appearing clear and transparent, while other minerals may be much weathered and, consequently, very dull. It also commonly encloses small crystals of other minerals, portions of the surrounding matrix, (in the case of rocks having a micro-felsitic or glassy base) and numberless minute fluid cavities (fig. 11.) Seen with polarised light, sections of quartz exhibit bright colours, pass-

ing from blue to yellow, or from red to green, as the polariser is rotated.

The microscope also reveals some interesting facts concerning the origin of quartz as a rock-forming mineral. Fig. 9 shows a section of an Alpine gneiss, in which the quartz is seen to be distinctly granular. In this form it has cooled from a state of aqueo-igneous fusion under great pressure, and represents the free silica, the remainder of this substance having gone to form felspar and mica, as the igneous paste cooled. And this is the common form assumed by those minerals which build up the plutonic and metamorphic rocks, so that both of these groups are said to have a crystalline-granular structure. In volcanic rocks, on the other hand, minerals may crystallise in definite forms, showing angular outlines in section (fig. 11); and there always exists between the crystals more or less of the original "paste" which has not assumed any definite crystalline form on cooling. (See figs. 1 and 2.)

Recent microscopical researches into the constitution of quartzose sandstones show that the quartz grains vary in outline according to size and mode of origin. In grits and conglomerates, for instance, the grains may be perfectly rounded; but in finer-grained sandstones they are usually sub-angular; while in excessively fine-grained rocks they may be quite angular. These facts are explained by the comparative ease with which coarse fragments can be rolled about on a beach, or in a water course, and the difficulty of eroding very small particles, which have not sufficient weight to be dashed against one another with any considerable force, even if their lightness did not cause them to be carried out into deep water.

A notable exception to this rule is found in the case of triassic sandstones, where extensive strata are found composed almost entirely of small grains of quartz having well-rounded outlines. It is probable that this form was impressed upon the grains before they reached the waters of the triassic sea. An examination of the sands of our deserts, where the particles are continually being shifted from place to place, blown

against hard rocks, and pushed over each other, shows that, under these circumstances, chips of quartz only one-fiftieth part of an inch in diameter may acquire perfectly rounded outlines. Such material being blown into the neighbouring seas and rivers must give a distinctive character to contemporary shallow-water deposits, more especially to those of inland seas, which are so frequently associated with desert tracts.

Felspar.—Of equal importance to quartz as a rock-builder is felspar, or, to speak more correctly, the felspars. Two of these, orthoclase and albite, are characteristic of those igneous rocks which, having a high percentage of silica, have been called the *acidic* group. The best known of the others (anorthite, labradorite, and oligoclase) are constituents of the intermediate and basic rocks, in which the percentage of silica ranges from 40 to 70. They all contain the silicate of alumina, and in addition one or other of the alkaline silicates, such as lime and soda. *Orthoclase*, a silicate of alumina and potash, seems to have a very wide distribution, being the most abundant mineral in the various granites and syenites. As *Sanidine* (a glassy variety), it is also a constituent of trachyte. Examined as a hand specimen, in a piece of coarse granite, such as that from Shap or Cornwall, orthoclase is readily distinguishable from the quartz and mica surrounding it. In colour it varies from white to a deep flesh colour; in hardness it is inferior to quartz, being difficultly scratched with a knife; flat shiny faces are common, and, with the other points mentioned, will readily serve to distinguish the felspar crystals from quartz granules. In the granites referred to, part of the felspar usually exists in what is known as the *porphyritic* state, crystals often 3 inches long being developed in a granular matrix of quartz, felspar and mica crystals. In rock surfaces exposed to the weather, orthoclase may lose all its most characteristic points, and become reduced to a soft, floury mass, easily scratched with a knife. In this condition, there is no danger of mistaking it for quartz. *Kaolin* is a name given to masses of granite which have become decomposed *in situ*

(Cornwall, &c.), and *Arkose* represents the weathered material consolidated once more as it stands. The unstable substance in orthoclase is the potash, which is gradually dissolved out by the percolation of carbonated waters, leaving only a clay behind. *Albite*, the soda felspar, frequently occurs in granites side by side with orthoclase (Newry and Cornish granites), and the two may possibly be distinguished by their behaviour when exposed to the weather. If a piece of granite contains reddish crystals in a fresh state, which are recognised as orthoclase, and also whitish crystals of felspar in an advanced stage of decomposition, the probability is that the floury crystals are those of albite. The earthy odour given out by many a conglomerate and grit when breathed upon is an evidence that decomposed felspar, or felspathic material, enters largely into their composition.

Applying this test to the grits and sandstones of the silurian and carboniferous systems, it is found that very few of them are purely quartzose, the majority containing rolled fragments of felstones. And this is specially noticeable in Shropshire, where cambrian and silurian conglomerates show by their structure that they are largely indebted for their existence to archæan felstones and syenites, relics of which still peep out at the surface in a score of places, from the Wrekin to Charnwood and the Malvern Hills.

Under the microscope, orthoclase felspar is not difficult to recognise. In granite, where it exists side by side with quartz, its floury character, pale red tint, greater abundance, ill-defined outlines, and absence of enclosures, will serve to distinguish it from the latter. In trachyte, on the other hand, the sanidine more nearly approaches the transparency of quartz; but its crystals in this case are well defined. It is a common thing to find them twinned, each half showing change of colour, chiefly shades of neutral tint, when examined with polariscope (fig. 3). The triclinic (plagioclastic) felspars are yet more liable to decomposition than orthoclase, owing to the increased quantities of alkalies present; so that, microscopically, they

tend to show a still greater lack of transparency. But a ready means of distinguishing them from orthoclase is to note the twinning, which is often developed to an extreme limit in plagioclase, several prisms being packed together in one mass, while in orthoclase only two crystals may be so joined (fig. 3). Another distinct character of basic felspars is the development of *fine striations*, frequently visible in microscopic sections, and serving at once to distinguish them from orthoclase (fig. 4). Groups of plagioclase crystals, roughly stellate in outline, are not uncommon in sections of igneous rocks, but orthoclase does not commonly assume this structure.

Felspar is of very wide distribution, and it is an exceptional occurrence to find an igneous rock in which it is absent. In some modern lavas its place is in great part occupied by *leucite and nepheline*, silicates of alumina and potash in the one case, and of alumina, soda and potash in the other. Sections of leucite lava are very instructive, showing the leucite to have some of the microscopic characters of quartz. The mineral is colourless and transparent, and frequently encloses crystalline fragments of other substances. Enclosures of magnetite are specially frequent, and concentric rings of this mineral indicate zones of growth in the leucite (fig. 2).

Mica.—Two varieties are common,—*muscovite*, a silicate of alumina, potash, and peroxide of iron, and *biotite*, a silicate of magnesia, potash, iron and alumina. Both may occur in acidic igneous and metamorphic rocks, the presence of at least one form being necessary in granite and gneiss, and may even range through the intermediate trachytes and diorites to the mica basalts amongst basic rocks. In each form the laminæ, or flakes, are *flexible and elastic*, muscovite being characterised in addition by its light colour and pearly lustre, and biotite by its very deep brown or greenish tint. Both are easily flaked with a knife, thus differing from hornblende. Under the microscope, with polariscope in use, the micas show double refraction strongly, whilst the well marked longitudinal striations indicating perfect basal cleavage, and the ragged

ends of the crystals render their identification comparatively easy.

Sections of obsidian and perlitic lavas often show mica flakes, surrounded by streams of tiny crystallites in such a manner as to suggest that the crystallisation of the mica must have occurred either in the volcanic neck, or in the igneous reservoir beneath, before the extrusion of the lava (fig. 1); and this will be true of other mineral crystals porphyritically developed in a non-crystalline base, when their *chipped corners* and association with *streams of crystallites* show that they were not developed during the cooling of the lava, but were borne along in the stream from below.

Hornblende, a silicate of magnesia, lime, alumina, and protoxide of iron, is a widely distributed rock forming mineral, being associated with orthoclase to form syenite, and with labradorite to form diorite. It may also occur as an accessory in granite, when the latter is said to become syenitic; or developed porphyritically in a finely granular matrix, producing hornblende porphyry; while sections of intermediate volcanic rocks frequently show that hornblende plays an important part in their structure.

Augite, another basic mineral, nearly similar in chemical constitution to hornblende, is with difficulty distinguished from the latter, as the two are so closely alike in external characters. Both are usually very dark in colour, and of nearly the same hardness—hornblende, perhaps, being slightly softer than augite. Consideration must be given to the surroundings of the doubtful mineral, as the two usually occur with widely different associations. Augite is more confined to basic rocks, such as diabase and basalt, where it is associated with the soda and lime felspars, olivine, &c. It follows, then, that the basic augitic rocks will be heavier than those (intermediate) in which hornblende occurs.

The microscope affords more certain means of determination. Sections of hornblende show frequently *two sets* of well-developed cleavage planes crossing each other (fig. 10), while

its dichroism is very strong, and changes of colour are shown. In augite, on the other hand, the cleavage planes are but faintly developed, and the dichroism feeble. Augite crystals, moreover, are very commonly aggregated in a stellate form, and they often show concentric zones of aggregation in their interiors (fig. 5). Cross sections of the augite prism are eight-sided, alternate sides being at right angles to each other, and those of hornblende six-sided. Both hornblende and augite may occur as constituents of the foliated metamorphic rocks (gneisses and schists); and, as in the case of igneous rocks, their presence will indicate that the silica is below seventy per cent., and the alkaline bases comparatively abundant.

Diallage, a silicate of magnesia, lime and iron, is a mineral closely allied to augite. It is specially interesting as being one of the constituents of gabbro, a basic plutonic rock, bearing much the same relation to granite and syenite that basalt does to rhyolite and trachyte. Gabbro occurs largely in the Hebrides, and is not unknown in other parts of Britain. In structure it is entirely granular, its component minerals being diallage and labradorite felspar. Under the microscope diallage shows strong basal cleavage, differing from augite in this particular, though resembling that mineral in its weak dichroism.

Olivine, a silicate of magnesia and protoxide of iron, occurs as *rounded crystals and granules* in basalt and other igneous rocks. It is of common occurrence in meteorites and ultra-basic rocks (silica below forty per cent.), and readily decomposes on exposure to the weather. In fact, olivine is one of the most unstable minerals the Geologist has to deal with; and many a mass of serpentine and steatite has resulted from an alteration of olivine rocks, the iron of which has been gradually removed, and the magnesia hydrated.

Microscropic examination usually shows that olivine is full of cracks, along the walls of which decomposition is setting in (fig. 6). Rounded corners are characteristic of its crystals, which, if transparent, will show brilliant colours when examined with polarised light.

Magnetite is another mineral common in basic rocks. It consists of the peroxide and protoxide of iron, and contains a larger percentage of that metal than any of the ferruginous minerals hitherto mentioned. Large shining black crystals are not uncommon in chlorite schist, but usually the mineral occurs as *minute specks and granules*. In this state, magnetite proves to have an extremely wide distribution, as it may occur in any igneous or metamorphic rock. It is, however, more characteristic of the basic volcanic rocks, in which its presence comes to be looked for as a regular thing. Sections of basalt appear very black under the microscope, from the large quantity of opaque magnetite granules present. In leucite and some other minerals it frequently forms zones of fine dust, the grains having been caught up from the surrounding paste, and enclosed during the growth of the crystals (fig. 2).

Garnet (another mineral containing iron, with silica and alumina) is of common occurrence in gneisses and schists, where it exists in a granular form. It is also found in certain igneous rocks, and is an important mineral in the crystalline granular rock eklogite. To a reddish colour it joins the hardness and lustre of quartz. No changes of colour are shown when microscopic sections of garnet are examined with polarised light, but the mineral is opaque when viewed with crossed nicol prisms (figs. 7 and 8).

Talc (a mineral rich in magnesia, with silica and water) is frequently developed in foliated metamorphic rocks, giving its name to such varieties as talc-slate and talc-schist. The mineral is very soft, and gives a greasy feel to the rock in which it occurs. The laminæ are flexible, but differ from those of mica in not being elastic; and the colour is white to greenish-grey.

Graphite is a mineral not uncommon in districts where metamorphic rocks abound, and, like talc and mica, it may give its name to those schists in which it is largely developed. It is easily recognised by its softness, metallic lustre, and property of making a black mark on paper.

LIVERPOOL GEOLOGICAL ASSOCIATION.

JUNE 15TH, 1885.

Evening Field Meeting, held this date at the Moor Hey Brick and Tile Works, Great Crosby, conducted by Mr. T. Mellard Reade, F.G.S. A section was here seen consisting of dark shale with bands of hard sandstone—the local equivalent of the New Red Marl—underlying the boulder clay; the upper part containing evidence of having been subjected to glacial action.

JUNE 27TH, 1885.

A joint Field Meeting with the Liverpool Science Students' Association was held this date at Hilbre Island, under the general superintendence of Mr. A. Norman Tate, F.I.C.

The effects of marine denudation, the massive jointing, and other interesting geological features of the island, were studied under the guidance of Mr. I. E. George.

JULY 6TH, 1885.

At the ordinary meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President, in the Chair, Mr. Frederick W. Edwards, Fairhope, Victoria Park, Walton, was proposed for membership.

DONATIONS.

Report of the British Association, 1884; *presented by Mr. J. C. Evans.* Catalogue of Fossils and Minerals in the British Museum; *presented by the President.* Fourteenth Report of the Chester Society of Natural Science; Proceedings of the Naturalists' Field Club, 1884–5; *presented by the respective Societies.* "Denudation of the Two Americas," and "The Drift Deposits of Colwyn Bay," by T. Mellard Reade, F.G.S.; *presented by the Author.*

EXHIBIT.

Rev. Mr. Paton exhibited a small case of American minerals from the New Orleans Exhibition.

A paper was read by Mr. William Semmons, on

NOTES ON SOME OF THE METALLIFEROUS DEPOSITS OF THE UNITED STATES.

Among the many potent factors which have affected the various markets of the world, the rapid development of the resources of the United States of North America is, perhaps, one of the most important.

Our purpose to-night is to consider briefly some of the developments of the Mineral resources of that country, and, though it would be impossible within the limits of a short paper to do anything like justice to the subject, we may perhaps be able to obtain some scraps of information by a brief examination of the modes of occurrence of some of the most important Metallic ores. In order, however, that our minds may not be altogether carried away with the somewhat sordid, though important, considerations of £ s. d., I purpose, in the first instance, to glance at some of those Minerals which have an interest to us as Mineralogists and Geologists.

Herderite.—First let us take the Mineral Herderite, one of the rarest of our European Minerals. This was found in the Tin mines of Saxony, and, according to Plattner and Turner, was an Anhydrous Phosphate of Aluminium and Calcium with Fluorine. A Mineral has lately been discovered at Stoneham, Maine, which is identical with the European Herderite, and, as sufficient quantities were found for analyses to be made, it was ascertained to be a Phosphate of Beryllium, Calcium and Aluminium. This led to a complete analysis of the Saxony Mineral being made, with the result of proving that it was in this respect, as well as in physical characters, identical with the Stoneham Mineral. This I consider one of the most interesting discoveries in Mineralogy for some little time past.

CRYOLITE.—Turning now to another group of rare Minerals we find that several of those interesting compounds of Aluminium, Sodium and Fluorine, which have been worked in Greenland only up to the present, have been found in the neighbourhood of Pikes Peak, Colorado. Not only do we meet with Cryolite, the ore of Greenland, but we also find those rarer compounds Gearksutite and Thomsenolite, with some other fluorides, the identity of which has not yet perhaps been absolutely proven.

TOPAZ.—Several fine crystals of Topaz were shown me at the office of the United States Survey in Denver by the finder, Mr. Whitman Cross, that came from the same locality. We shall therefore, I think, when this district is worked, have some further interesting compounds found here. Topazes have been found in other localities in the United States, but space forbids our dwelling on them.

EMERALD.—In North Carolina for some few years past mining operations have been carried on for the extraction of Emeralds. These, although not equal as gems to those from some other localities, are of good colour and sometimes of fair size. The largest crystal found was 8½ inches long, and weighed 9 ounces. The veins containing the Emeralds are not seen at the surface, and hence are called blind veins, and the prevailing rock is a species of Gneiss. Many years ago, the farmers are reported to have picked up these "Green Bolts" in their fields and sold them to collectors, but this mode of supply has failed long since. The Emeralds are found in pockets, one of which contained over 70 crystals. Associated with these Emeralds were beautiful crystals of Rutile and other minerals, the most interesting, perhaps, of which was a beautiful green transparent Spodumene, to which the name of Hiddenite was given.

HIDDENITE.—This Hiddenite occurred in large numbers in some of the Emerald pockets, frequently 40 of them to one Emerald. They are harder and have more fire and brilliancy than their better known associate, and rarely contain any

flaws. The crystals are usually very small, the largest being a little over two inches long, and I am informed the largest gem cut weighed about 2½ carats. As an instance of a gem containing that comparatively rare element Lithia, and one new to science, this Hiddenite is, I think, worthy of special notice.

Tourmaline.—We must notice, though briefly, the Tourmalines of the United States. At various points in the State of Maine they are found in magnificent crystals, and of the most charming colours. Green, blue, pink and yellow are met with, and in some there are bands of these colours superimposed on a single crystal. The enormous and brilliant crystals (black) from Pierpont, New York, and the fine brown crystals from Governour in the same state, are well represented in our national collection at South Kensington.

Rock Crystal.—Some of the most beautifully clear crystals of the mineral quartz are met with near Lake George, so famous for its reminiscences of the War of Independence. These are often doubly terminated, and contain a large number of cavities, most of them with liquid inclusions. In some of them, small crystals, also clear, can be seen lying at a different angle from the larger crystal which forms their environment, giving us the idea of a temporary suspension of deposition, then a deposition of another character from that under which the original crystal was deposited, and then again a resumption of the original character. Most charmingly do they reveal to us some of the complicated and beautiful changes that have gone on in Nature's laboratory.

Near the Hot Springs, Arkansas, large quantities of clear quartz crystals, covering considerable spaces, are blasted by the farmers during the winter, and sent to market. This beats jam making all to pieces. The American farmer can turn his hand to anything, and has even been cute enough to meet the taste of those who imagine that rolled pebbles of quartz cut the best, as he coolly puts the quartz just blasted into a box, and by rolling the crystals therein makes pebbles to any extent required.

The large masses of Amethyst Quartz, one 5 feet by 2 feet, I saw at Lake Superior, I think, were equal in colour to any I have seen from the best known localities.

Tellurium.—Having thus briefly glanced at some of the minerals which are of interest in themselves, and of themselves as a whole, I will now proceed to some which are of interest from their metallic contents. First, we will examine some of those combinations of that subtle element Tellurium. The State of Colorado is especially famous for them, as we meet with Hessite, Sylvanite, Nagyagite, Tellurite, Coloradoite and others, together with crystals of the element in a native state. Quite recently, the telluride of Nickel has been found. Some of these tellurides occur in sufficient quantities to be mined as ores, and greatly contribute to the enormous total of the precious metals produced by the State. Among the vast improvements in Metallurgical science may be named that of the extraction of the precious metals from these Tellurides with comparatively little loss. The works of the Boston and Colorado Smelting Company at Denver, where these ores are smelted, are conducted with the highest scientific skill by my old friend and teacher, Mr. Richard Pearce, F.G.S., whose great local knowledge is so well known to all visitors, and which he most liberally places at their service. The return of Colorado in 1882 is given in the official United States returns, as Gold, 3,360,000 dollars.

Silver, 16,500,000 dollars.

Some of these Tellurides are found filling up the vacancies between boulders of Trachyte in the veins, and seem to be a cementing material with some other ores. The boulders are of all sizes, and may be considered, as Professor Emmons says, as a loose pile of water worn stones, which have been loosely thrown into a pit. These boulders in the Bassick mine are covered with no less than five distinct layers (concentric) of different minerals. Each layer is parallel to the surface of the nucleus, and, strange to say, all the layers follow the same order round the various boulders. Had we space we might with profit dwell on these peculiar and valuable deposits.

LEAD.—The production of Lead in the United States has advanced by "leaps and bounds," till, in 1882, the official returns give a total of no less than 132,890 tons. In 1825, the production was 1500 tons.

To show the importance of the Rocky Mountain district, we may mention that the official estimate for 1882 gives a production for Colorado, 58,642 tons.

Utah	- 30,000	,,
Nevada -	8,590	,,
Idaho -	5,000	,,
Montana	4,500	,,

and as Missouri, Illinois, and Kansas are returned as 29,015 tons, it follows that the other States of the Union produce only a small proportion of Lead.

The extra cost of production, owing to the high wages of the miners and the heavy transit charges, is compensated for by these ores almost always containing silver. In fact, it is quite usual to hear Lead ores spoken of as 40, 50 or 100, meaning ounces of silver per ton, the Lead being considered as a mere bye-product. It is through this cause that the Western States have been able to produce with the ruinous prices for Lead that have been ruling for some time. The main portion of the mining in Colorado is centred at Leadville, the "City of the Clouds" as it is well called. The mining operations are carried on at an elevation of 10,000 to 12,000 feet above the level of the sea, and it has taxed the ingenuity of our Western cousins to the utmost in counteracting the peculiar atmospheric conditions consequent on such an elevated platform of work.

The Lead Ore appears to be principally found at the contact of the Limestone (known there as Blue Limestone) of Carboniferous age with the overlying white Porphyry. This Porphyry is spoken of as a blanket deposit, from its being spread over a large district, almost horizontally. The principal mass of the Lead ores is found in the Calcareo-Magnesian rocks, while the Siliceous rocks contain proportionately more Gold and Copper.

The Lead ores are principally Carbonate (Cerussite) and Sulphide (Galena), and they are sometimes associated with Copper, Bismuth, Zinc and other metallic ores. The probable manner in which these enormous deposits have been laid down has received much attention from the able geologists attached to the Survey, and though some still hold to the old idea of direct deposit from solution, most of them are inclined to consider that these mineral treasures have been formed by a metamorphic or pseudomorphic action of the waters, containing mineral solutions, on the rocks themselves. These waters are supposed to have derived their metallic contents from the various eruptive rocks in which they have circulated, and then to have acted along the planes of bedding of the sedimentary rocks. By this method we get rid of many of the difficulties associated with the varying width of the metallic contents. I might mention in passing, that this theory of replacement has been adopted by many practical men lately, in connection with the Tin deposits of our Cornish mines.

The great unsolved problem of the Leadville district is, whether the deposit extends underneath the city itself; and the general impression is that it does. If this be so, the importance of this district in the future of Lead can hardly be over-rated. The records of the Leadville district give the following interesting figures as to its production:—

1877........	175	tons of Lead.
1878........	2,324	,, ,,
1879........	17,650	,, ,,
1880........	33,551	,, ,,
1881........	38,101	,, ,,
1882........	39,864	,, ,,
	131,665	tons.

The ores are generally low in produce, say from ten to twenty per cent. of Lead, higher per centages being uncommon.

I was fully prepared to see some fine smelting works, but

those of the Grant and Omalia Company at Denver, which, through the kindness of Mr. Eddy and Governor Grant, I was able to inspect, surpassed in extent and completeness of detail anything I had previously met with. The water jacket furnaces, syphons for tapping, and the methods by which the gases and fumes are drawn off below the level of the charge door, are marvellous proofs of the ingenuity of the workers, while the blocks of ice, with water playing thereon to reduce the temperature, the blue spectacles for the workmen, and other little precautions, testify alike to the value placed on the labourer, and the solicitude of the employer. It would perhaps be worth naming here, that though, as a rule, mineralogical curiosities are rare among the Lead ores of America, the exquisitely delicate crystals of Wulfenite (Molybdate of Lead), with the colour of honey, which seem like thin plates of the most fragile glass, are among the most beautiful of our minerals, while the recently discovered crystals of the Vanadiate of Lead, with their terminations exactly corresponding to the isomorphous phosphate, completely surpass anything of the kind from any other locality.

Tin.—With the marvellous accumulation of metallic ores that the United States has been blessed, there seems to be one important item comparatively unrepresented, viz., the metal Tin. Fortunate indeed is this to our Cornish and Australian miners, for, were a discovery of importance made, the consequences to them would be most fatal. The fact that in 1882 no less than 10,500 tons of Tin as bars, blocks and pigs were imported, as well as about 4¼ million boxes of Tinplates, speaks volumes as to importance of this metal to the country. At isolated spots all over the Union, in California, Texas, Montana, Idaho, Maine, Tin ore has been found, but although the reports thereof have frequently affected prices, the finds have been usually of mineralogical interest only. In Alabama, however, an attempt has been made to work some thin veins of Stanniferous Gneiss. The results are reported in euphonious language, as "not commercially successful," but as the

number of men in raising the ore averaged four, the quantity sent to market was necessarily very trifling.

Of late, there has been a great stir as to the existence of Cassitterite in the Black Hills of Dacotah. A great many experts have been sent to the locality, and it has thus been fairly examined in the past year. So far, we have had no heavy returns of the metal, and in more than one case a peculiarly heavy mineral, Tantalate of Lime, was found by chemical analysis to be the actual representative of the supposed Tin ore. Cassitterite undoubtedly exists in the Black Hills, but so far no "paying" deposits have been found. It seems as if in that sprinkling of useful metals which, according to some, Dame Nature favoured the continents with a few thousand years ago, America was overlooked in the Tin department. Perhaps all her lapful was used up in the Eastern hemisphere This, however, is only a theory, the absence of the metal, so far, is a fact. The total output of metallic Tin in the world is probably somewhat under 40,000 tons per annum.

ZINC.—Zinc ores are found in many localities in the United States, and the total production of the metal is very large, having grown from 7,343 tons in 1873 to 33,765 tons in 1882, and as the Western smelters have largely extended their producing power, this latter quantity is now, no doubt, considerably exceeded.

The deposit of Zinc ores near the town of Franklin, New Jersey, is a most remarkable one. It is frequently called a Zinciferous Granite, from its resemblance to that well known rock. It is composed of Zincite *(oxide of zinc)*, Willemite *(anhydrous silicate of zinc)*, and Franklinite (*oxide of manganese, zinc and iron)*. The Willemite is considered to represent the Felspar; the Zincite the Mica; and the Franklinite the Quartz of Granite. Though, of course, the colour of Franklinite differs from that of Felspar, there is a strong resemblance of the mass, as a whole, to some Granites. The deposit which is compared to a chimney, is bounded by limestone walls, and is traversed by numerous trap dykes,

These chimney like deposits are also found in Pennsylvania, where large deposits of a most peculiar Blende, accompanied by Calamine (of Dana), have been worked. The Blende is of a bluish slate colour, and has a clear ring when struck. The quality of the metal made from this ore is remarkably fine, and is well known to the trade. An interesting deposit of zinc ores is worked on the open Prairie in that portion of Missouri which adjoins Kansas. The blende here seems to be the cementing material in a Breccia, composed of angular pieces of Flint or Chert. It is a bed like deposit, which has been worked for over half a mile square, and is generally covered by a bed of limestone and chert.

The general impression seems to be that the Zinc mines of America are not worked in as profitable a manner as they should be, but with the gigantic industries everywhere this does not seem surprising, and in a few years, no doubt, it will be rectified.

COPPER.—The dominant position now occupied by the United States in the production of Copper renders it important to consider, at somewhat greater length, the various deposits of this metal. Before the war of 1861, large quantities of Copper were imported; now, not only is this state of things reversed, but the export of the metal is so large and seems so capable of extension, that the market price is largely regulated according to the views held by European capitalists of the immediate or future action of American mine owners. The following is the production of Copper in the past few years, and, for the purpose of comparison, I give the productions of some other noted localities.

	1879.	1882.	1884.	
United States	23,350	39,300	63,950	tons.
Spain and Portugal	32,000	38,500	43,500	,,
Chili	49,000	43,000	41,648	,,
Australia	9,500	9,000	13,300	,,
England	3,462	3,464	2,500	,,

The year 1885 will probably show a still further advance of the United States over other countries.

Almost all the States in the Union have yielded Copper Ores, but the Eastern States only produce a small proportion of this large total. The principal points of production at present are the Lake Superior district, Montana, and Arizona.

ARIZONA.—The production of Arizona in 1882 was about 10,000 tons of Copper, almost exclusively from Carbonates and Oxides, and Silicates, and, as yet, but little has been done on the underlying Sulphuret Ores. The Copper districts are scattered all over the Territory, and one feels quite amazed at the quantity produced, when it is remembered that only a few years since the Indians gave great trouble, and even now have to be watched; that the district has been but slightly opened out by railways; and that the summer heats are most trying both to prospectors and permanent works.

LAKE SUPERIOR.—The Lake Superior district is by far the most important producer at present. In 1882 it produced over 25,000 tons, and this year the production will probably be over 35,000 tons. In fact, the production of the district might be almost doubled if the mine owners cared to do so, and this without unduly working the reserves. Leaving Duluth, the "Zenith City of the unsalted Sea," by the fine lake steamers, one crosses Lake Superior, to the narrow point of land which juts out into it, called Keewenaw Point, in about 24 hours. A short canal has been cut from the little Portage river to the western shore of the Point, and some very interesting results were arrived at as to the recent elevation of the land here. The change from the Lake to the Canal was at once perceived by the difference in the motion of the vessel, and this awoke me. On looking out of my cabin, I found we were in a canal with high hills on both sides, and the hills covered with dense pine forests or their remains, as the lumber men had been at work on them.

The cliffs were composed of a reddish yellow sandstone, resembling much the Trias near Liverpool. This fact is confirmed by T. Mellard Reade, F.G.S., who has examined my specimens. This resemblance is intensified by the beds of

clay and sand containing boulders, which were seen overlying the sandstone along the shores of the Lake and the Canal.

At Hancock, where the steamer stops for some time, there are large smelting works by the banks of the Canal. The mineral is brought down from several of the mines by a small railway, on which the full wagons, by means of gravity, pull the empty ones up the hill.

Going up the hill towards the belt of mines which lead toward the famous Hecla and Calumet mine, I noticed large boulders of Granite, Gneiss, Felstone, and Greenstone were scattered all over the surface, some of them being strongly Ice marked.

ICE MARKINGS.—Glacial markings can be seen, too, where the rock has been laid bare, even up to the summit of the hill, which must be 800 feet above the Lake. At the pit mouths, large heaps of stuff were lying about, some of them being masses of pure copper, at least 5 cwt. In some of these I found little patches of silver of a few ounces, while smaller ones could be met with frequently.

The Lake Superior Copper Belt, as the district is termed, is no less than 130 miles long, and in some places is about six miles wide. It consists of a series of alternating Trappean rocks and Conglomerates.

Except just at one point, where a remarkable series of Arsenides of Copper, Whitneyite, Domeykite and Algodonite are found, the Copper is met with in the pure native state, and the metal derived therefrom is of remarkable purity.

It is found as Mass Copper, Barrel work and Stamp work. The large masses of Copper formerly constituted by far the largest part of the production, and weigh frequently hundreds of tons. One mass from the National Mine weighed over 1000 tons. In this Mass Copper frequently are found veins of pure metallic silver, and occasionally beautiful crystals and filaments of the noble metal. "These masses are remarkable, not only as minerals, but as the largest masses of any single element known in the earth's crust."

Barrel work, so called from the blocks being packed in barrels for the smelting works, consists of small blocks of metallic Copper from 1 to 5 cwt. each. The greater part of the Copper now raised in the district is, however, obtained from Stamp work, which produces from three quarters per cent. in the Atlantic mine, to five per cent. in the Hecla and Calumet. Speaking generally, we may call the Stamp work from two to three per cent. of Metallic Copper.

Strange to say, it is found much cheaper to work this low produce Stamp work than the large masses of Copper. The mechanical arrangements for breaking, raising and stamping the stuff are on the most approved and scientific principles, and the ingenuity of the Americans is taxed to the utmost in the substitution of machinery for manual labour.

The Copper occurs according to the Reports:

1. As true fissure veins.

2. Filling the vescicles of amygdaloidal Melaphyres.

3. As an accessory constituent of an epidote rock lying between the Melaphyres.

4. As the cementing material of a Breccia lying between sheets of Melaphyre, as in the great Hecla and Calumet deposit.

The Crystals of Native Copper are usually found in modified cubes, and other forms of the cubic system. Many pseudomorphs are, however, met with after Calcite and Zeolitic minerals. As these Zeolites, and particularly Calcite have been formed long since the protrusion of the Igneous rocks, the Copper deposit seems to be a much later deposit than these beds.

It is interesting to notice that the existence of Copper at Lake Superior was known to the Jesuits in the 17th century. Probably it was known long before, as much of this Mass Copper was worked at the surface. It appears that in 1845 the first Copper mine is reported as being worked in the United States, and the total production that year was 100 tons, of which 12 tons came from Lake Superior.

MONTANA.—Turning now to the district which has become a formidable rival to Lake Superior, we notice the Territory of Montana, the development of which is only as yet in its infancy. The growth of the district is marvellous, and the unsolved problem is whether this growth is to continue, or whether it has overshot itself. For many years Montana has been known as a producer of Gold and Silver. I saw Placer mining for Gold near Helena, and all along the Crest of the Divide from Butte to Helena were traces of old Placer heaps, the refuse of the Gold miners. One little hamlet, where now only three or four families live, was, I was told, only a few years since a prosperous township. The houses, having been built of wood, had been taken down, and thus transferred to another locality. At Helena, the capital of the Territory, there is still alluvial or Placer Gold mining carried on by Chinese, but the waste heaps testified to the former works of this description being on a much larger scale. It was in this district that the famous Vigilantes of Montana, only a few years since, took the law in their own hands and restored peace and order to the locality. It would make this paper too long if I dwelt on the Gold production, and I therefore return to the Copper Mines. These are principally situate in the neighbourhood of Butte City, which is now a mining camp of several thousand miners. These Copper mines were formerly worked for Silver, and large quantities of the precious metal were obtained. This Silver has been found in two conditions. (1) As a constituent of rich Copper Ores; (2) As a constituent of Manganese leads or veins.

It has been noticed that several veins which, eastward of the town of Butte, are rich in Copper, become, as they are traced west, less rich in that metal, and become manganiferous with an increased quantity of Silver. These two belts are known as the Copper belt, and the Manganese belt. In the Eastern belt, the country rock is a coarse grained hard Granite containing more than the normal quantity of Quartz and Mica. In the Western belt the rock becomes very micaceous, and is arranged in parallel layers resembling Mica Schist.

The quantity of Copper produced from this Butte camp has surprised all observers, and at present it looks as if, with only a moderate price for the metal, the mines could return enormous quantities at a profit. It is estimated 30,000 tons fine Copper per annum could be easily extracted if desired.

The principal ores are Chalcocite and Erubescite, with small quantities of Copper Pyrites, and occasionally masses of Enargite.

Very few crystals of either of these minerals have been found in the locality as yet, though I did meet with some of Enargite. This peculiarity has been noticed by nearly all the mining experts who have visited the locality.

Chalcocite is the most plentiful ore in one set of veins on which the far famed Anaconda Mine is worked, whilst Erubescite constitutes the principal mineral of the Parrot group of mines. It is stated that Copper Pyrites is making its appearance in the deeper levels of both veins.

Thin films of Native Silver are found along minute fissures, which occur in the Chalcocite, as if it had seggregated out from its cheaper companion.

Erubescite also occurs in massive deposits, and, so far, I have not heard of any crystals being found.

Enargite occurs massive and in small crystals. Its characters are similar to specimens from other localities. This mineral has been found here in much larger quantities than in any other place. It seems to be rather a common ore in fact throughout the Rocky Mountain district, and its decomposition has given rise to a most interesting series of combinations in the Battle Mountain district of Nevada. Strange to say, the immense Copper deposits of Montana show no traces of their existence at the surface, except a few stains of Carbonate of Copper, and Oxides of Iron and Manganese on the Quartzose outcrops of the veins. We look in vain for the Gossan of the Cornish mines, or those products of decomposition, the Arseniates and Phosphates. As far as mineralogical curiosities are concerned, it is almost a blank.

The great Copper deposits of North America are, therefore, composed of distinct classes of mineral, viz.:—The Native Copper of Lake Superior, The Sulphides of Montana, The Carbonates and Silicates of Arizona and Southern California. In addition, there are the Pyrites deposits of the Eastern coast, which contain a small percentage of Copper.

IRON.—Passing through a lumber district in Michigan, we come across a most interesting Iron district.

The little county of Marquette produces about twenty per cent. of the Iron ores in the United States. Near Negaunee are the celebrated Republic and Superior mines. The Ore is found in large deposits of Schistose Hematite, known as Iron Slate or Specular Schist. These sometimes pass into bands of solid Hematite, or sometimes Jasper with bands of Hematite. Granular and compact varieties of Magnetite are also met with, and it is here we meet with the Octahedral variety of Hematite, known as Martite. The Champion mine, where one of the largest deposits of the district is met with, contains a huge lenticular mass, of which the Eastern portion is a black magnetic ore, while the Western portion consists of Specular slaty ore, with only a little Magnetite. At Jackson mine, Negaunee, I noticed an immense open working of, apparently, interstratified beds of Shale and Hematite. The workings are probably about half a mile long, and 200 feet wide at the top. It is, in fact, an open quarry, and immense quantities of ore have been extracted.

There appears to be no limit to the capacity of the district as far as production is concerned. There are other large deposits of iron scattered over the Union, so that the question of transit seems the only one that is likely to interfere with the consumption being entirely supplied from home sources.

It is not within the scope of this paper to notice the deposits of Coal and Lignite, which are found over so many States of the Union, nor have we to deal with the deposits of the precious metals, except those which came under my immediate notice in Colorado and Montana.

Enough, however, has, I think, been described of the various localities, where the baser metals are being worked, to show that Nature has endowed the North American Continent with a profusion of metallic wealth. In fact, with the exception of the single metal, Tin, it would appear that the United States is likely not only to produce sufficient for its own wants, but also to compete in foreign markets with those countries which have for a long time supplied them with metals.

LIVERPOOL GEOLOGICAL ASSOCIATION.

JULY 11TH, 1885.

Field Meeting held this date at Hightown. The structure and mode of formation of the Sand-dunes was explained by Mr. C. Potter. A peat bed resting on laminated blue clay was examined in a section exposed on the shore between Hightown and Blundellsands. Mr. I. E. George showed that this peat bed consisted of the compressed remains of sedges and other aquatic plants, with, in a few instances, the roots of trees, well preserved, penetrating into the blue clay underneath.

JULY 25TH, 1885.

Field Meeting held this date at St. Helens, conducted by Rev. S. Gasking, B.A., F.G.S. Sections of Coal Measures were examined at Doulton's Delf and Moss Bank Quarry, upright trunks of *Sigillaria* were seen, with roots penetrating the underclay, and specimens of fossil ferns and other plant remains were collected.

AUGUST 3RD, 1885.

On this date, instead of the ordinary meeting at the Free Library, a Field Meeting was held at Pontesbury, near Shrewsbury, conducted by Mr. I. E. George.

At *Nils Hill*, Quartzites were seen exposed in some quarries, varying from coarse grits to fine grained sandstones, with siliceous cement. In these were found rain pittings, sun cracks and ripple markings, indicating that the sediment was accumulated in shallow water, during slow and long continued subsidence of the shore line. Worm burrows were also found in abundance, and in some places, bitumen was found filling the joints of the rocks,

These rocks belong to the stiper stone series of lower silurian age.

Pontesford Hill was next visited. It consists of a mass of felstone, probably of pre-Cambrian age, and is penetrated by basalt of more recent age. The view gained from the summit was very comprehensive, extending from the Wrekin and Caradoc Hills to the distant Peckforton Range, Berwyn Mountains, and Plinlimmon.

An examination of the blocks littering the sides of Pontesford Hill proved them to be museums of geological interest. Some of them were highly vescicular, and looked not unlike the toadstone of Derbyshire.

Passing towards the Longmynd, were next seen the purple grits, shales and conglomerates of Cambrian age, many pebbles in the conglomerates being found identical with the rhyolite of Pontesford Hill, pointing to the relative ages of the two rocks.

At Lyd's Hole, a fault has brought the Archean Rhyolite into contact with the purple shales and sandstone.

AUGUST 22ND, 1885.

Field Meeting held this date at Kirkby Moss, conducted by Mr. I. E. George. Sections of peat resting on drift sand and boulder clay were seen, and some sections were traced of old water courses existing before the formation of the peat.

SEPTEMBER 5TH, 1885.

The last Field Meeting of the season was held this date at Thurstaston, conducted by Mr. C. E. Miles. A visit was made to a deep ravine, locally known as the "Dungeon," excavated out of triassic sandstone, and displaying sections of an important fault, where ripple marked keuper sandstones are brought into contact with hard sandstones of Bunter age,

SEPTEMBER 7TH, 1885.

At the ordinary meeting, held this date at the Free Library, Mr. C. E. MILES, Vice-President, in the chair,

Mr. Frederick W. Edwards was elected a member, and Mr. James Wilding, 92, Troughton Street, was proposed for membership.

DONATIONS.

"The Mersey Tunnel in its Geological Aspect," by Mr. T. Mellard Reade, F.G.S.; *presented by the Author*. Transactions of the Mining Association of Cornwall, vol. i., part 1; Transactions of the Manchester Geological Society, vol. xviii., part 10; Proceedings of the Geological Association, London, vol. ix., No. 2; *presented by the respective Societies.*

Mr. W. H. Miles and Mr. T. R. Connell were elected Auditors.

A Lecture on

"SILICA"

was delivered by Mr. Geo. Tate, Ph.D. F.G.S., who exhibited numerous mineral specimens in illustration of his lecture.

JOHN DONALD, PRINTER, 556, PRESCOT ROAD, OLD SWAN.